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# Spraying Program

## and Pest Control for Fruit Crops

OHIO
AGRICULTURAL EXPERIMENT STATION
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# Contents




Bulletin 128 — "SPRAYING PROGRAM AND PEST CONTROL FOR FRUIT CROPS,"
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# Spraying Program

## and Pest Control for Fruit Crops

THE MANY orchards in Ohio represent a wide range in conditions such as: age of trees, location, cultural practices, varieties, and suspectibility to insects and diseases. A spray program cannot be formulated that will meet the requirements of each individual orchard. Seasonal variations, orchard cultural practices, and general environmental conditions largely govern the severity of both fungous diseases and insect outbreaks. For these reasons some orchards may require a rigid or complete spray program to control pests, while in others during the same season, such a program may not be necessary.

Spraying should be looked upon as a form of insurance. Important sprays should not be omitted unless the grower is reasonably certain that he can afford to carry the risks that will develop in the absence of spray protection.

Changes in spraying procedure becomes necessary from year to year. This is due in part to the ever-changing conditions concerning the pests against which the treatments are directed, and in part to the development of new sprays and to new information concerning older ones. Rapid advances are being made in perfecting spraying materials, and new ones continue to appear.

This bulletin discusses the standard spray materials now offered for sale, and suggests proper combinations that will control both insects and diseases without causing spray injury to the fruit and foliage. It has been prepared after considerable discussion of the effectiveness and safety of the materials and combinations suggested; these having been thoroughly tested and approved.

The three main considerations in successful spraying are: *correct timing, thorough application,* and the *use of proper materials.* These are the "big three" responsible for success in spraying, and if any one is neglected the structure falls, for without all three of them success cannot be attained.

### The Ohio Spray Service

The Ohio Spray Service is entirely informational, and deals largely with the timing of sprays. From a small beginning in a few counties, it has grown until now the entire state is included.

The information is distributed by the Extension Service of the College of Agriculture, and is of two general types: (1) letters, and (2) radio broadcasts. The information upon which recommendations

are based is collected from all parts of the state and assembled at Columbus. Suggestions on the necessary spraying procedure are then sent to the county agents, who in turn notify every fruit grower on their mailing lists.

Each fruit grower is sent a letter for each apple spray. No further information is necessary for the dormant spray. For the preblossom sprays, a letter is mailed in advance giving all the necessary information, except the time of application. The time for spraying is announced over the radio for each fruit section. The exact time and place of broadcasting is sent each spring to all fruit growers on the mailing lists.

The calyx spray is timed by the fall of the petals and no further information is necessary than that contained in a letter. Information regarding the ten-days to two-weeks spray is disseminated over the radio. The dates for applying the codling moth cover sprays are given in letters sent to the individual growers; the time for spraying varies for the different fruit sections. These letters are supplemented by weekly radio broadcasts.

Every fruit grower in Ohio is entitled to receive the spray information. This service is free. Apply to county agent in your county.

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## Spray Programs for Control of Insects and Diseases

### The Apple Spray Program

Within recent years the apple spray program has become more complicated; first, because codling moth has grown more destructive in certain parts of the state and, second, because of the increasing necessity of avoiding excess spray residues on the marketed product. Because of these facts, it is no longer possible to recommend a uniform schedule applicable to all conditions; therefore, two different codling moth spray schedules are offered.

The first of these schedules is proposed for use in orchards in which codling moth has not increased greatly in abundance. This schedule is so arranged that under seasonal conditions in which rainfall is normal, there should not be a residue of either lead or arsenic in excess of amounts permitted by present regulations.

The second schedule is proposed for use in the so-called "problem" orchards in which codling moth is not controlled by the restricted schedule. A special effort is made in this schedule to control the early season brood of codling moth, and arsenicals are continued in the late season sprays for later broods. It must be clearly understood that *it will be necessary to wash the harvested fruit* in dilute hydrochloric acid if this schedule is applied.

# Five Stages of Apple Bud Development

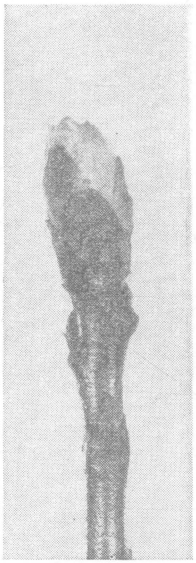

Fig. 1.—Green bud stage.

Fig. 2.—Delayed dormant stage.

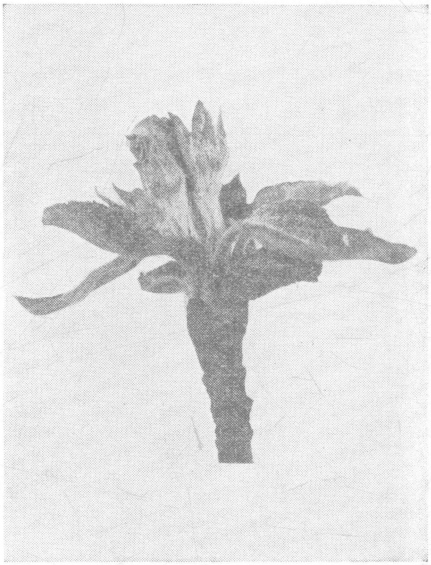

Fig. 3.—Pre-pink stage.

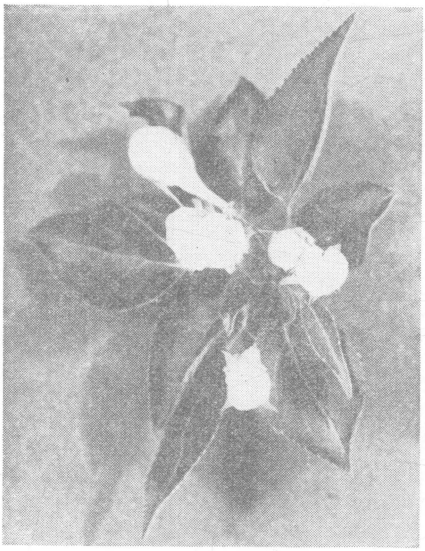

Fig. 4.—Pink stage.

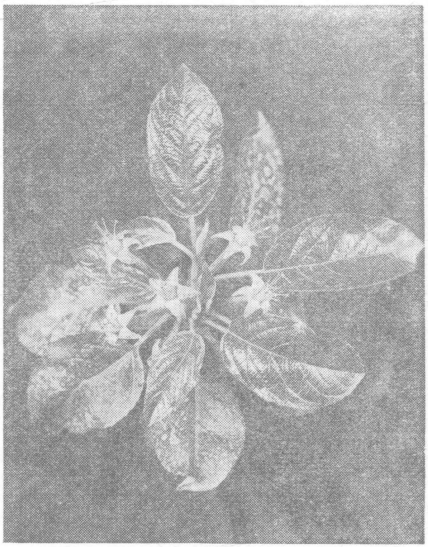

Fig. 5.—Calyx cup stage.

The spraying schedules are divided into periods numbered 1 to 5, and the individual sprays of each are designated by letters a, b, and c.

## APPLE SPRAY PROGRAM — FOR ALL ORCHARDS

| | Name and Time of Spray | Materials to Use | To Control | Further Suggestions |
|---|---|---|---|---|
| *1* | **(a) Dormant**<br>In spring when buds are dormant or beginning to swell. | Oil emulsion carrying 3% oil or miscible oil at manufacturers' recommendations<br>(See page 17) | Scale<br>Red mite | Oils can be applied safely up to the green bud stage. They sometimes cause burning in the delayed dormant.<br>For use of tar oils and "dinitro" oils against rosy aphis, see page 16. |
| *2* | **Pre-blossom**<br>(a) Delayed Dormant<br>When blossom buds show ½ inch green. | **Liquid lime-sulfur. 2 gals.<br>Water to make.....100 gals. | Scab | If rosy aphis is a problem, add 1 pint of nicotine sulfate to 100 gallons of the lime-sulfur spray. |
| | (b) Pre-pink<br>Following delayed dormant and before petals show. | **Liquid lime-sulfur. 1½ gals.<br>Water to make.....100 gals.<br>(For flea-weevil control, see footnote) | Scab<br>Black rot<br>(Frog-eye)<br>Flea-weevil<br>(see note) | On varieties such as Baldwin, Grimes, Jonathan, and Golden Delicious, where lime-sulfur may cause serious russeting or leaf injury, the reduction of strength of lime-sulfur, *or*, the addition of 5 lbs. of hydrated lime, *or*, the substitution of flotation type sulfur is advisable (see page 24). |
| | (c) Pink<br>After blossom stems separate and before bloom opens.<br>(Watch Spray Service recommendations)<br>Finish in bloom if necessary. | *Flotation type sulfur 12 lbs.<br>*or*<br>**Liquid lime-sulfur. 1½ gals.<br>Water to make.....100 gals.<br>(For need of arsenical see suggestions at right) | Cutworms<br>(see note)<br>Scab<br>Black rot<br>Cankerworm<br>(if present)<br>Flea-weevil<br>(see note) | If cankerworms are troublesome, add 3 lbs. of lead arsenate and 5 lbs. of hydrated lime in the Pink. |
| | **Spraying in early bloom is advisable if scab threat is serious. Do not apply lead arsenate at this time.** | | | |
| *3* | **Calyx Cup**<br>When the last of the petals are falling. | *Flotation type sulfur 10 lbs.<br>Lead arsenate..... 3 lbs.<br>Hydrated lime..... 5 lbs.<br>Water to make.....100 gals. | Scab<br>Codling moth<br>Curculio<br>Cankerworm | If red-bugs or leafhoppers are present add 1 pint of nicotine sulfate.<br>Lime is added to decrease burning.<br>(Cover all blossoms) |

* For convenience or where flotation sulfur is not available, use a wettable sulfur at manufacturers' recommendations. See pages 23 and 24.

** For convenience, dry lime-sulfur, 8 lbs. in 2(a) or 6 lbs. in 2(b and c), can be substituted for the liquid lime-sulfur.

NOTE: If apple flea-weevil is a problem, it is recommended that the following formula be used in the pre-pink and pink sprays:

| | |
|---|---|
| Dutox or Kalo Spray | 5 lbs. |
| Flotation type sulfur | 12 lbs. |
| Goulac | 8 oz. |
| Water | 100 gals. |

During the past four seasons this formula has given excellent control of flea-weevil, and with timely thorough spraying has controlled apple scab, where preceded by lime-sulfur in the delayed dormant.

In addition to Dutox and Kalo Spray, other fluorine sprays, such as natural and synthetic cryolite, have been used successfully. Fluorine sprays kill climbing cutworms.

It is very important that the underside as well as the upperside of the foliage is covered.

## FOR ORCHARDS WITHOUT SERIOUS CODLING MOTH PROBLEM

| NAME AND TIME OF SPRAY | MATERIALS TO USE | TO CONTROL | FURTHER SUGGESTIONS |
|---|---|---|---|
| *4* (a) **Ten Days to Two Weeks** After petal-fall. (Watch Spray Service recommendations) | *Flotation type sulfur.. 8 lbs.<br>Lead arsenate ..... 3 lbs.<br>Hydrated lime ..... 5 lbs.<br>Water to make.....100 gals. | Scab<br>Curculio<br>Blotch | This spray is very important where scab has not been controlled in the pre-blossom period, *or*, if overwintering scab spores are still being discharged. Do not delay application beyond 10 days where curculio is a problem.<br>Use 2-4-100 bordeaux mixture for blotch in southern Ohio. |
| (b) **First Brood Codling Moth Sprays** Three to four weeks after petal-fall. (Watch Spray Service recommendations) | Same as 10-days to 2-weeks spray, except as noted under Suggestions.<br>See Suggestions. | Codling moth<br>Curculio<br>Scab<br>Blotch<br>Brooks spot | Flotation type sulfur may be used in all localities except where copper sprays are needed.<br>In Southern Ohio localities where Brooks spot and blotch are serious, use 2-4-100 bordeaux mixture.<br>(Coat every apple thoroughly) |
| (c) **Six Weeks Cover Spray** Two weeks after 4(b) (See under Suggestions) | Lead arsenate ..... 3 lbs.<br>Hydrated lime ..... 5 lbs.<br>Water to make.....100 gals.<br>(Do not apply this spray on Duchess and other early varieties)<br>See Suggestions. | Codling moth<br>Apple maggot | This spray is very important where codling moth is increasing and in some Northeastern Ohio orchards where apple maggot is a problem.<br>Where Brooks spot is to be combated, replace the lime with 2-4-100 bordeaux; where bitter rot is a problem use 4-6-100 bordeaux. Additional applications may be necessary in hot, humid weather. |
| *5* **Second Brood Cover Spray** Nine to ten weeks after petal-fall. (Watch Spray Service recommendations) | *Flotation type sulfur.. 6 lbs.<br>Zinc or calcium arsenate ..... 3 lbs.<br>Hydrated lime ..... 8 lbs.<br>Water to make.....100 gals. | Codling moth<br>Apple maggot<br>Bitter rot<br>Blotch<br>Brooks spot<br>Sooty fungus | Avoid spraying if possible when temperature is abnormally high, or spray injury may follow. Foliage injury from calcium arsenate may be expected unless 8 lbs. of lime is used. Zinc arsenate is less likely to cause foliage injury.<br>For Brooks spot and blotch use 2-8-100, and for bitter rot use 4-8-100 bordeaux mixture.<br>(Coat apples thoroughly) |

* For convenience, or where flotation sulfur is not available, use a wettable sulfur at manufacturers' recommendations. See pages 23 and 24.

NOTE: Zinc and calcium arsenate are not as effective against codling moth as lead arsenate. The use of lead arsenate in the second brood cover spray may leave too much lead residue. Thorough brushing, or wiping of fruit could be expected to remove only a little of it. See page 29 for substitutes for arsenicals in this spray.

# FOR ORCHARDS HAVING A SERIOUS CODLING MOTH PROBLEM

## SPRAY PROGRAM TO BE FOLLOWED BY WASHING

| NAME AND TIME OF SPRAY | MATERIALS TO USE | TO CONTROL | FURTHER SUGGESTIONS |
|---|---|---|---|
| 4 **First Brood Cover Sprays**<br>(a) Ten days after petal-fall. | *Flotation type sulfur.. 8 lbs.<br>Lead arsenate .....3½ lbs.<br>Hydrated lime ..... 5 lbs.<br>Water to make.....100 gals. | Curculio<br>Codling moth<br>Scab<br>Blotch | In addition to the control of early hatching codling moth, this spray is necessary: (a) where curculio is a serious problem, (b) where new leaves have some scab lesions, or (c) on varieties susceptible to blotch. Use 2-4-100 bordeaux for blotch control in southern Ohio. |
| (b) Two weeks later. | Lead arsenate ..... 3 lbs.<br>Summer oil..... 2 qts.<br>**Hydrated lime ..... 5 lbs.**<br>Water to make.....100 gals.<br>**(Sulfur fungicide cannot be used with summer oil. Bordeaux 2-4-100 should replace the lime** in the above in southern Ohio where blotch or Brooks spot is serious) | Codling moth<br>Curculio<br>Scab<br>Blotch<br>Brooks spot | For those who do not desire to use summer oil, or, where apple scab has not been controlled, use 3½ lbs. of lead arsenate, lime and flotation type sulfur without oil as in 4 (a). |
| (c) Two weeks later. | Lead arsenate ..... 3 lbs.<br>Summer oil..... 2 qts.<br>Hydrated lime ..... 5 lbs.<br>Water to make.....100 gals.<br>(Use no fungicide with this spray unless bitter rot is a problem, in which case replace the lime with 4-6-100 bordeaux mixture) | Codling moth<br>Apple maggot | This spray protects the fruit at the peak of first brood codling moth hatching. |
| (d) Two weeks later. | *Flotation type sulfur.. 6 lbs.<br>Lead arsenate ..... 3 lbs.<br>Hydrated lime ..... 5 lbs.<br>Water to make.....100 gals. | Codling moth<br>Apple maggot<br>Bitter rot<br>Scab | Use 4-6-100 bordeaux mixture where bitter rot is a problem.<br>Use of summer oil in this or later sprays will make residue removal difficult. |
| 5 **Second Brood Cover Sprays**<br>(a) Two weeks after 4(d)<br>*or*<br>9-10 weeks after petal-fall. | *Flotation type sulfur.. 6 lbs.<br>Lead arsenate ..... 3 lbs.<br>Hydrated lime ..... 5 lbs.<br>Water to make.....100 gals. | Codling moth<br>Bitter rot<br>Apple maggot<br>Brooks spot<br>Sooty fungus<br>Blotch | Avoid spraying if possible when temperature is abnormally high or spray injury may follow.<br>For Brooks spot and blotch use 2-4-100 and for bitter rot use 4-6-100 bordeaux mixture.<br>(Coat apples thoroughly) |
| (b) Two weeks later. | Lead arsenate ..... 3 lbs.<br>Hydrated lime ..... 5 lbs.<br>Water to make.....100 gals.<br>(Fungicide usually not necessary) | Codling moth | Avoid spraying in extremely high temperature.<br>In most "problem" orchards this will be the last spray needed. Further spray applications necessary only under extreme codling moth infestation. |

*For convenience, or where flotation sulfur is not available, use wettable sulfur at manufacturers' recommendations. See pages 23 and 24.

## Distribution of Some Apple Pests in Ohio

One of the reasons that a general apple spray program for Ohio must be somewhat complicated is the peculiar and unequal distribution of some diseases and insects. In general, there are four distinct diseases controlled by sprays, namely, scab, Brooks spot, blotch, and bitter rot. Scab is general throughout the state, and the regular sulfur sprays should be used to protect against it.

Brooks spot, blotch, and bitter rot are confined largely to the southern apple growing section. For their control, bordeaux mixture, as recommended, is the most effective spray at present.

Scale insects, red mite, codling moth, flea-weevil, and curculio are generally distributed. Codling moth is annually a serious problem in


Fig. 6.—Distribution of apple maggot.

Fig. 7.—Distribution of Brooks spot.

Fig. 8.—Distribution of bitter rot.


**Fig. 9.—Distribution of cedar rust. (Not readily controlled by sprays)**

Lawrence, Ottawa, and parts of Lucas and Sandusky Counties. The spray schedule on page 8 is recommended for some orchards in this area. Apple maggot and red bug are troublesome only in northeastern Ohio, the apple maggot covering a much larger area and being more injurious than the red bug.

## Varietal Susceptibility to Disease and to Spray Injury

There are marked differences in degrees of susceptibility and resistance to scab of the various varieties of apples. There are also great differences in susceptibility and resistance of the different varieties to spray russeting. Fortunately for the orchardist, it usually happens that the varieties of apples most susceptible to scab are those most resistant to russeting by caustic spray. On the other hand, those apple varieties very easily and seriously russeted by spraying are so inherently resistant to scab that only very mild and safe formulas are necessary to keep the disease under control.

In the following table is listed the susceptibility of different varieties to diseases and to spray injury. By observing these facts in one's orchard it is possible to make certain changes in the general spray recommendations to better fit the individual orchard.

Apple scab and fire blight attack vigorously growing trees more frequently and severely than trees of low vitality. The opposite is true of black rot and apple measles. Trees making poor growth are likely to be injured by sprays which do not harm vigorously growing trees of the same variety. The margin of safety for effective sprays is narrow, and constant search is being made for safer and better materials.

*Degree of Susceptibility of Ohio Apple Varieties to Diseases and Spray Injury*

| Variety | Scab | Bitter Rot | Blotch | Brooks Spot | Fire Blight | Cedar Rust | Bordeaux Russet | Lime-Sulfur Russet |
|---|---|---|---|---|---|---|---|---|
| Baldwin | Moderate | Moderate | Slight | Slight | Slight | Slight | Very | Very |
| Ben Davis | Very | Very | Moderate | Slight | Slight | Slight | Very | Very |
| Cortland | Very | Moderate | Very | Slight | Very | Moderate | Slight | Slight |
| Delicious* | Very | Moderate | Slight | Moderate | Slight | Moderate | Slight | Moderate |
| Duchess | Moderate | Slight | Very | Slight | Slight | Slight | Slight | Slight |
| Golden Delicious | Slight | Very | Moderate | Very | Slight | Slight | Very | Very |
| Grimes | Slight | Very | Slight | Very | Very | Slight | Very | Very |
| Jonathan | Slight | Very | Slight | Very | Very | Moderate | Very | Moderate |
| McIntosh | Very | Very | Very | Slight | Slight | Slight | Slight | Moderate |
| N. Spy | Very | Moderate | Slight | Slight | Slight | Slight | Slight | Slight |
| R. I. Greening | Moderate | Very | Slight | Slight | Moderate | Slight | Moderate | Moderate |
| Rome | Very | Moderate | Moderate | Moderate | Moderate | Very | Slight | Slight |
| Stayman | Moderate | Moderate | Slight | Moderate | Slight | Slight | Moderate | Moderate |
| Wealthy | Moderate | Slight | Slight | Slight | Moderate | Moderate | Slight | Slight |
| Winter Banana | Very | Very | Slight | Slight | Slight | Moderate | Moderate | Moderate |
| Yellow Transparent | Moderate | Slight | Slight | Slight | Very | Slight | Slight | Slight |

* Varieties like Delicious, Rome, Stayman, etc., include the red sports of those varieties.

# PEAR SPRAY PROGRAM

| NAME AND TIME OF SPRAY | MATERIALS TO USE | TO CONTROL | FURTHER SUGGESTIONS |
|---|---|---|---|
| **Dormant**<br>Before buds open, or when beginning to swell. | Oil emulsion carrying 3% oil<br>*or*<br>Miscible oil | Scale<br>Pear psylla<br>Blister mite<br>Red mite | This spray is necessary only in case one or more of these insects are serious. |
| **Cluster Bud**<br>When blossom buds are separated in the cluster and before blossoms open. | Flotation type sulfur.. 12 lbs.<br>Water to make.....100 gals. | Scab<br>Leaf spot | This spray may be omitted where disease is not prevalent. |
| **Calyx Cup**<br>When the last of the petals are falling. | Flotation type sulfur.. 10 lbs.<br>Lead arsenate..... 3 lbs.<br>Hydrated lime..... 5 lbs.<br>Water to make.....100 gals. | Codling moth<br>Scab<br>Leaf spot<br>Pear-slug<br>Sooty fungus | Spray blossom clusters thoroughly. |
| **Midsummer**<br>Nine to ten weeks after petal-fall. | Flotation type sulfur.. 8 lbs.<br>Zinc or calcium arsenate 3 lbs.<br>**Hydrated lime ..... 8 lbs.**<br>Water to make.....100 gals.<br>(See suggestions at right) | Same as for calyx cup. | Lead arsenate will give better control and is advised if washing equipment is available.<br>Avoid spraying if possible when temperature is abnormally high. |

# PEACH SPRAY PROGRAM

| NAME AND TIME OF SPRAY | MATERIALS TO USE | TO CONTROL | FURTHER SUGGESTIONS |
|---|---|---|---|
| **Dormant**<br>In the fall after leaves are shed or in spring before buds swell. | Liquid lime-sulfur... 6¼ gals.<br>Water to make.....100 gals.<br>*or*<br>6-8-100 bordeaux. | Leaf curl | Leaf curl is best controlled by fall spraying with liquid lime-sulfur.<br>If scale is present, double the **strength of liquid lime-sulfur,** or use oil spray combined with 6-8-100 bordeaux in very early spring application. See page 19.<br>Fall application of oil on peach is not advised because of possibilities of injury. |
| **Shuck-Fall**<br>When shucks are splitting and falling from the expanding fruits. | Zinc sulfate..... 1 lb.<br>Hydrated lime..... 2 lbs.<br>Lead arsenate..... 2 lbs.<br>Water to make.....100 gals.<br>*or*<br>90-10 lime-lead dust (see page 43). | Curculio | Do not apply unless curculio is a problem.<br>If lead arsenate without zinc sulfate is used add 10 pounds of lime to avoid burning.<br>Peach is very susceptible to arsenic injury. Be sure lime used is fresh. |
| **Two Weeks**<br>Two weeks after the shuck-fall. | Flotation type sulfur.....8 lbs.<br>*or*<br>Wettable sulfur, commercial or home-made (p. 23).... 6 lbs.<br>Water .....100 gals.<br>*or*<br>90-10 sulfur-lime dust (see page 43). | Brown rot<br>Scab | This is a very important peach scab spray. |
| **Pre-harvest**<br>Ten days to two weeks before the fruit is picked. | Use materials as recommended for two weeks application. | Brown rot<br>Scab | Flotation type sulfur, wettable sulfur, or sulfur-lime dust leaves very little residue on the harvested fruits. |

**Oriental Fruit Moth.**—No spraying schedule can be recommended at this time that will give satisfactory control of this insect. Experimental work with parasite introduction is in progress, and promising.

# SPRAY PROGRAM FOR PLUMS

| NAME AND TIME OF SPRAY | MATERIALS TO USE | TO CONTROL | FURTHER SUGGESTIONS |
|---|---|---|---|
| **Dormant**<br>When the tips of the buds first show green but before leaf tips are visible. | Oil emulsion carrying 3% oil<br>*or*<br>Miscible oil<br>*and*<br>Nicotine sulfate..... 1 pint<br>Water to make.....100 gals. | Red mite<br>Scale | |
| **Shuck-Fall**<br>When shucks are splitting and falling from the expanding fruit. | *Fixed copper (based on 25% metallic).. 3 lbs.<br>Lead arsenate..... 2 lbs.<br>Hydrated lime..... 3 lbs.<br>Water to make.....100 gals. | Curculio<br>Brown rot<br>Leaf spot | This is one of the most important sprays for stone fruits. |
| **First Cover**<br>Ten days to two weeks after shuck-fall spray. | Same as for shuck-fall, except **omit lead arsenate.** | Brown rot<br>Leaf spot | |
| **Second Cover**<br>7 to 10 days before harvest. | Flotation type sulfur.. 8 lbs.<br>*or*<br>Wettable sulfur ..... 6 lbs.<br>Water to make.....100 gals. | Brown rot<br>Leaf spot | Sulfur dusts without lead may be applied during harvest whenever brown rot threatens.<br>A discussion of wettable sulfurs is given on pages 23-24. |

# SPRAYING PROGRAM FOR CHERRIES

| NAME AND TIME OF SPRAY | MATERIALS TO USE | TO CONTROL | FURTHER SUGGESTIONS |
|---|---|---|---|
| **Dormant (see note) | (see note) | Black cherry aphis | Sour cherries rarely require a dormant spray. |
| **Shuck-Fall**<br>When the shucks are splitting and falling from the expanding fruits. | *Fixed copper (based on 25% metallic). 3 lbs.<br>Hydrated lime..... 3 lbs.<br>Lead arsenate..... 2 lbs.<br>Water to make.....100 gals. | Leaf spot<br>Curculio<br>Brown rot<br>Slug | In some seasons an earlier application may be advisable for leaf spot. Watch Spray Service recommendations. |
| **First Cover**<br>Two to three weeks after the shuck-fall spray. | Same as shuck-fall, except omit **lead arsenate.** | Leaf spot<br>Brown rot | This is a very important leaf spot spray. |
| **Second Cover**<br>When fruits are beginning to color. | Same as shuck-fall, except omit **lead arsenate.** | Leaf spot<br>Brown rot | This is a very important disease spray.<br>If cherry maggot is a problem, include 2 lbs. of calcium arsenate, then wash fruit to remove residue. |
| **After Harvest**<br>Immediately after fruit is picked. | Same as shuck-fall, except omit **lead arsenate, unless slugs are present. (See note under Further Suggestions.)** | Leaf spot | This spray is important to protect the foliage. Cover leaves thoroughly. Trees which drop their leaves in mid-summer set poor fruit buds.<br>If slugs are present, include 2 lbs. of lead arsenate. |

* A discussion of fixed copper compounds is given on page 27.

** NOTE — If black cherry aphis is a problem on sweet cherries use Tar oil, or "di-nitro" oil according to the manufacturers' directions. Use only in full dormant period. This insect may also be controlled with 2 gals. of liquid lime-sulfur and 1 pint of nicotine sulfate per 100 gals. spray applied in the delayed dormant period.

## Spray Program for Young Fruit Trees Not Yet Bearing

Young trees not yet into bearing, with the exception of sour cherries, should receive when necessary a dormant spray for control of scale, aphis, and red mite. Scale frequently causes serious injury to young neglected trees before the owner realizes they are infested.

Peach trees should receive a dormant spray for leaf curl, as given in the peach schedule (page 11).

Apple trees should receive the regular apple scab sprays during April and May to prevent scab infection on the leaves and possible defoliation. These should be continued up to and including the two weeks after petal-fall spray. Where cankerworms are present lead arsenate and lime should be included in the full pink application. In midsummer, spray with lead arsenate and lime if caterpillars appear.

Cherry trees should receive the fungicide sprays for protection against cherry leaf spot. If slugs are present, lead arsenate should be included.

Young peach trees should be carefully inspected at least twice each year for peach tree borers, and the gas treatment given on pages 47 or 49 should be applied if necessary. Young apple trees should be inspected each year in late August and all borers cut out. If over 5 per cent of the trees are infested with round headed borers, the trees should be wrapped with newspapers in early June of the following year.

## Facts About Spraying Grapes

It is impossible to construct a spray schedule for grapes that will have general application. The insect and disease problems of vineyards located in different communities, and even in vineyards of the same community, are frequently quite variable. For example, grape mildew, while serious on the Lake Erie islands and at the west of Lake Erie, is rarely a problem in the commercial grape belt east of Cleveland. Rose chafer usually is troublesome only in vineyards with sandy soil. Many grape insects are quite localized in their distribution.

In many vineyards of recent plantings, and in some mature vineyards, excellent grapes are frequently grown without any sprays. In other plantings two, or at the most three spray applications will control the troubles present. Only a few vineyards will require the full spray schedule.

Each grower should study his conditions and apply only such sprays as are found necessary. Thoroughness is very essential; berry-moth and leafhoppers cannot be controlled, except by very thorough applications. Good pressure and careful adjustment of spray nozzles and boom are essential.

# GRAPE SPRAY PROGRAM

| NAME AND TIME OF SPRAY | MATERIALS TO USE | TO CONTROL | FURTHER SUGGESTIONS |
|---|---|---|---|
| **Delayed Dormant**<br>When buds show ½ inch green. | 8-10-100 bordeaux mixture. (see page 25).<br>*and either*<br>Resin fish oil soap[1].....2 lbs.<br>*or*<br>Fish oil[1].....1 pint | Black rot | In wet years and in localities where black rot has been serious.<br>Watch out for injury to buds by climbing cutworms (see page 47).<br>Where berry-moth is serious, plow to vines as soon as soil can be worked. Plow under all fallen leaves and trash in which cocoons are located. Do not work soil again until after bloom. |
| **Pre-blossom**<br>Before blossom buds open. When the new shoots are 10 to 12 inches long. | 6-8-100 bordeaux mixture.<br>*and either*<br>Resin fish oil soap[1].....2 lbs.<br>*or*<br>Fish oil[1].....1 pint | Mildew<br>Black rot | Necessary only in case these diseases are present. Cover all leaves and bud clusters.<br>Watch for rose chafers which may appear just before bloom and destroy blossom buds. If they appear, spray with 8 lbs. of lead arsenate and 2 gals. of molasses in 100 gals. of bordeaux or water. |
| **Petal-Fall**<br>(Immediately after blossoming) | 4-6-100 bordeaux mixture<br>*and*<br>Lead arsenate .....3 lbs.<br>*and either*<br>Resin fish oil soap[1].....2 lbs.<br>*or*<br>Fish oil[1].....1 pint | Berry-moth<br>Mildew<br>Black rot<br>Leafhoppers (see under suggestions) | Very important where berry-moth is serious. Dissolve the soap in hot water and add to bordeaux, with agitator going.<br>If young leafhoppers are numerous on the underside of the leaves, add ⅔ pint of nicotine sulfate and, with high pressure, force the spray against underside of leaves. |
| **Repeat Spray**<br>Seven days after petal-fall spray. | Same as for petal-fall spray.<br>(To avoid lead residue 2½ lbs. of calcium arsenate[2] may be substituted for the lead arsenate in this spray) | Berry-moth<br>Root-beetle<br>Black rot<br>Leafhoppers (see under suggestions) | Very necessary where berry-moth is serious. Be sure to cover fruit clusters.<br>If young leafhoppers are numerous, apply nicotine sulfate as directed under previous application.<br>Soil plowed for berry-moth control can now be worked down. |
| **Special Root Beetle Spray**<br>Early in July when first feeding marks are seen on leaves. | Fixed copper compound and lime according to manufacturer's direction<br>*and*<br>Calcium arsenate[2].....2½ lbs.<br>Water to make.....100 gals | Root-beetle | Necessary only where root-beetle is serious. Watch for chain-like feeding marks on leaf and spray only upper surface of leaves. |
| **Special Leafhopper Spray**<br>In late June or early in July as soon as leafhoppers are hatched. | Fixed copper compound and lime according to manufacturer's direction,<br>*and either*<br>Resin fish oil soap[1].....2 lbs.<br>*or*<br>Fish oil[1].....1 pint<br>*and*<br>Nicotine sulfate .....⅔ pint<br>Water to make.....100 gals. | Leafhopper | This special spray is sometimes necessary where nicotine spray has not been previously made in order to control leafhoppers and prevent "rusty" foliage Direct against insects as advised in Petal-fall spray. |

[1] One of these materials is necessary as a spreader and sticker. Laundry soap can be substituted but is more difficult to dissolve.

[2] Arsenicals should not be applied to the berry clusters later than the "Repeat Spray" because of the residue remaining on the harvested fruit.

# SMALL FRUITS SPRAY PROGRAM

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## GOOSEBERRIES AND CURRANTS

| NAME AND TIME OF SPRAY | MATERIALS TO USE | TO CONTROL | FURTHER SUGGESTIONS |
|---|---|---|---|
| **Delayed Dormant**<br>In the spring when buds show ¼ inch green. | *Liquid lime-sulfur.. 12½ gals.<br>Water to make.....100 gals.<br><br>Nicotine sulfate..... 1 pint<br>(Used only in case aphis is troublesome) | Scale<br>Anthracnose<br><br>Aphis | Oil emulsion 4½ gallons or miscible oil at manufacturers' recommendation is preferred for scale if anthracnose is not a problem. The nicotine may be added to the oil if aphis is to be combated. |
| **First Cover Spray**<br>Just after the first leaves have unfolded. | Bordeaux mixture 4-6-100<br>*or*<br>*Liquid lime-sulfur.. 1½ gals.<br>Water to make.....100 gals. | Anthracnose<br>Leaf spot | |
| **Second Cover Spray**<br>Ten days to two weeks after first cover spray. | Bordeaux mixture 4-6-100<br>*or*<br>*Liquid lime-sulfur.. 1½ gals.<br>Lead arsenate..... 2 lbs.<br>Water to make.....100 gals. | Anthracnose<br>Leaf spot<br>Currant worm<br>Powdery mildew | If the fruits are more than one-half grown 4 lbs. of ground derris root should be substituted for lead arsenate. If mildew is a problem use lime-sulfur instead of bordeaux. |
| **After Harvest Spray** | Bordeaux mixture 4-6-100<br>*or*<br>*Liquid lime-sulfur.. 1½ gals.<br>Water to make.....100 gals. | Leaf spot<br>Anthracnose<br>Powdery mildew | |

* Dry lime-sulfur may be substituted for liquid at the rate of 4 pounds for 1 gallon.

### STRAWBERRIES

As a commercial practice, spraying strawberries for the control of leaf spot is not advised. The growing of resistant varieties like Premier is recommended.

For the control of the strawberry leaf roller, dust with a fluorine bearing material (Kalo, Kryocide, Alorco, or Dutox) at the rate of 1 part of the insecticide to 2 parts talc and 2 parts flour; or spray with the same material, using 5 pounds of the insecticide with an acceptable spreader, such as sulfated alcohol or Goulac, in 100 gallons of water. Make the first application when the tiny larvae first appear and before leaves are folded. Do not apply any one of these materials after any fruits are more than ⅓ grown.

If an application is needed when berries are more than ⅓ grown or when fruits are ripening use pyrethrum (Dry Pyrocide, Red Arrow) or powdered derris root at recommended strengths to prevent fluorine residue. Fluorine treatments may be resumed when the second brood of larvae appears after the crop is harvested.

### RASPBERRIES AND BLACKBERRIES

Only one spray is advised on raspberries and blackberries. A delayed dormant application just as the buds are showing green, using liquid lime-sulfur 5 gallons or 20 pounds of dry lime-sulfur to make 100 gallons of spray, is advised. No material for summer control of anthracnose or powdery mildew has been devised which will give control and not result in spray injury.

Spraying is not advised for virus or bacterial diseases (mosaics, streaks, curls, crown gall). Control of these diseases is secured by planting *disease-free* stocks in isolated locations.

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## SPRAYS FOR DORMANT USE

The orchardist has a choice of several spray materials for use in the dormant season, according to his particular needs. Each of the different materials, which will be discussed in detail, is fitted for certain situations that may arise in Ohio orchards. These materials are:

1. Tar-distillate emulsions
2. Petroleum oils with an extra killing agent added
3. Petroleum oils, which may be divided as:
   (a) Ready mix oils
   (b) Miscible oils
   (c) Oil emulsions (factory and home-made)
4. Lime-sulfur for use on peaches

### Tar-distillate Emulsions

These oils are derived from the distillation of coal and gas tars, and have been used successfully in the United States and in many foreign countries for the control of the rosy apple aphis. Tar oils are sold under several trade names and are known to be very effective against aphis eggs when used in dilutions carrying not less than 2½ per cent of the oil. They must be applied when the tree is *completely* dormant, as serious injury may result if buds are showing any green.

The chief value of tar oils is in the control of rosy aphis rather than green aphis, because of the summer migration habit of the latter species. Objections to the use of tar oils are: (1) infrequency of serious rosy aphis outbreaks in Ohio orchards, (2) failure to control San Jose scale and red mite eggs unless combined with petroleum oil, (3') high cost of the tar oil-petroleum oil combination, and (4) irritation to skin of spraymen and horses. For these reasons tar oils have a very restricted use in Ohio apple orchards.

### Petroleum Oils with Added Killing Agent

In past years the idea has developed that oils might be made more efficient by the addition of other toxic materials. This has been accomplished recently by the combination of dinitro-O-cyclo-hexylphenol with oil. This product is then emulsified in the spray tank according to the manufacturers' directions and applied to trees in the usual manner. As in the case of tar oils, it is highly effective against aphis eggs. It also has some value against eggs of the European red mite.

Ohio trials have not yet established its efficiency against San Jose scale, but reports from experiments in other states are favorable in this respect. The use of this spray must be confined to the *dormant period,* and spraymen and horses should be protected from excessive drift.

## Petroleum Oils

Petroleum oils are widely employed for dormant spraying due to their (1) low cost, (2) efficiency in pest control, (3) non-corrosive action on spray machinery, and (4) general agreeableness of use. As

Fig. 10.—Branches on right show injury to the buds by a 6 per cent dormant oil spray applied when the buds were breaking. Left, branches were not sprayed.

now sold on the market, these oils are of many different types. In general, however, any of them will fall in one of the three following groups. If used at proper strengths there is no difference in effectiveness in any of these groups.

(a). *Ready Mix Oils.*—These are oils which have combined with them a small amount of emulsifying agent so that the process of emulsification may be completed by the orchardist in the spray tank just before spraying. They have the advantage of carrying a higher percentage of oil than do other types and, therefore, the amounts used can be somewhat reduced.

(b). *Miscible Oils.*—Oils of this type have the emulsifying agent incorporated in them as a solution. They are in reality an oil solution of the emulsifier, which is usually a soap. They contain a relatively high amount of oil, averaging from 80 to 90 per cent. Most of them mix readily with water. In most cases they are higher in price than the other oils.

(c). *Oil Emulsions.*—These may be purchased already prepared from commercial companies or they may be made at home. They contain less oil than the other groups. Therefore, a heavier dosage is required. This disadvantage, however, is overcome by their lower cost, and the ease with which they can be mixed in the spray tank (see page 19). The commercially prepared emulsions are convenient and appeal to the small growers, who do not object to the additional cost of the factory mixed product.

### *Preparation of Home-made Oil Emulsions*

For those growers who prefer to make their own emulsions, it is important that the proper oil be secured. Lubricating oil falling within the following specifications is correct and can be secured from many oil companies:

Viscosity..... From 90 to 140 seconds at 100° F. (Saybolt)
Volatility..... Less than 2 per cent
Specific gravity..... From 0.88 to 0.91 at 68° F.

Under no circumstances should motor oil or waste oil from crankcases be used.

In preparing the oil emulsion, either of the following formulas may be used:

FORMULA I

| | |
|---|---|
| Lubricating oil | 3 gals. |
| Water | 1½ gals. |
| Copper sulfate | ½ lb. |
| Hydrated lime | ¾ lb. |

Dissolve the copper sulfate in half the water and add the solution to the oil. Next, mix the lime with the remainder of the water and add this to the oil-copper sulfate mixture. Pump twice through spray nozzle at pressure to exceed 100 pounds. The copper sulfate and lime in this mixture are emulsifiers and have little fungicidal value.

In order to avoid delay and the inconvenience of dissolving the copper sulfate each time the spray tank is filled, it is suggested that a stock solution be prepared before the spraying season starts.

Take the number of pounds of copper sulfate that is needed for the spray operation and suspend it in a sack in the same number of

gallons of water as you have pounds of copper sulfate. Suspend the copper sulfate just beneath the surface of the water in a wooden barrel, or earthen jar. The crystals will dissolve overnight, or, warm water may be used to hasten it, if desired. This gives 1 pound of copper sulfate to every gallon of solution. Therefore, if ½ pound of copper sulfate is called for, simply use 4 pints of solution.

FORMULA II

| | | |
|---|---|---|
| Lubricating oil | 3 | gals. |
| Water | 1½ | gals. |
| Calcium caseinate | 6 | oz. |
| or | | |
| Goulac (dried waste sulfite liquor) | 6 | oz. |

In preparing this formula, sift calcium caseinate or Goulac into the water while stirring briskly until the amount specified has been added. Add the oil to the calcium caseinate or Goulac solution and pump twice through the spray nozzle at a pressure to exceed 100 pounds. Where extremely hard water must be used, double the amount of emulsifier.

### *Diluting Formulas for Use*

It is recommended that for San Jose scale and red mite a dilute spray carrying 3 per cent oil should be used in the dormant season. Either of these formulas, as given, will make a spray containing 3 per cent oil when diluted to 100 gallons in the spray tank. If the tank holds 200 gallons, use two times the quantity of each material in the formulas. If a 300-gallon tank is used, multiply each material in the formulas by three to obtain the required amount.

Either of the preceding formulas may be combined with 6-8-100 bordeaux mixture for use on peaches, as an early spring dormant spray.

### *Tank Mixing of Oil Sprays*

(Preferred method in commercial orcharding)

While a stock solution may be stored for future use (with some risk of breakdown), it generally has been found that either formula given can be used to better advantage by mixing each tankful separately and applying immediately.

With Formula I this is done as follows: Place in the tank about 3 gallons of water for each 100-gallon capacity of the tank. More or

less water may be used, but in any case, it should cover the suction intake. Pour in the required amount of copper sulfate solution and, with agitator running, sift in the lime. With this solution, pour in the oil (3 gallons for each 100-gallon capacity of the tank) and pump back into the tank until it is emulsified; that is, no free oil showing. Water is then added to fill the tank with agitator running. It should be sprayed on the trees as soon after as possible.

Formula II is prepared in the same order; first add the 3 gallons of water, then sift in the calcium caseinate, or Goulac, with the agitator running, add the oil, and pump back into the tank until it is emulsified. Then fill the tank as above.

Tank mixing with Formulas I and II avoids the curdling of the stock emulsion that usually occurs if it is stored even for a few days. Tank mixing is the method usually followed.

**☞ Cautions in Use of Petroleum Oil Sprays:**

1. Some oil sprays stand freezing, others *do not.* Know the kind you are using and protect from cold if it is in the latter class.

2. *Do not* spray with oils if temperatures are below 40°; or if low temperatures are forecast for the next 24 hours.

3. *Do not* spray with free oil floating on top of the spray solution.

4. Oils are used most efficiently during the period that buds are swelling, but when the leaf tips begin separating, their use should be stopped. In some seasons oils used in the delayed dormant period, and especially oil emulsions, have been safe. In others, severe injury to buds has resulted.

## Lime-Sulfur

Previous to the introduction of oils, lime-sulfur was universally used for dormant spraying in Ohio. The chief objections to the use of dormant strength lime-sulfur are: (1) high cost of dilute spray; (2) failure to control red mite; and (3) its irritation to the eyes and exposed parts of the body of the operator. For these reasons it is declining in favor and is no longer recommended as a dormant spray except on peaches.

For the control of peach leaf curl there is no spray superior to lime-sulfur if applied when the trees are dormant. If scale is not a problem, lime-sulfur can be used on peaches at one-half the strength recommended for the control of scale insects.

Dry lime-sulfur can be held over from one year to another without deterioration if kept in air-tight containers. Liquid lime-sulfur, when held over winter, should be stored where it will not freeze, and sealed to exclude the air. The freezing point of concentrated liquid lime-sulfur is much below the freezing point of water. If the material has been allowed to freeze it should be tested with a Baumé hydrometer before using. (See table below.)

Of recent years there has been an increased interest on the part of growers in making their own lime-sulfur. Where some equipment and the necessary time is available a reduction in the cost of spray materials can be affected. Two convenient pieces of apparatus for making lime-sulfur are a steam coil heated by a boiler, and a large container like a concrete cistern or steel tank for storage. Storing all the home-made lime-sulfur in one container eliminates the necessity of testing each barrel separately for Baumé reading. Farmers' Bulletin 1285, obtainable for 5c from the Superintendent of Documents, Washington, D. C., or Bulletin 572 of the Ohio Agricultural Experiment Station gives full directions for making lime-sulfur concentrate.

More detailed information about the properties of lime-sulfur and other sulfur compounds is given under "Sulfur Fungicides," on page 22.

*Amounts of Liquid Lime-sulfur for Dormant Spraying on Peaches, and Pre-blossom Spraying on Apples at Different Baumé Readings*

| Hydrometer reading | Amounts per 100 Gallons of Spray | | | |
|---|---|---|---|---|
| | Peach—Dormant Spray | | Apple | |
| | Scale present | No Scale | Delayed dormant 2-100 | Pre-pink and Pink 1½-100 |
| Degrees Baumé | Gal. | Gal. | Qt. | Qt. |
| 33 | 12½ | 6¼ | 8 | 6 |
| 32 | 13½ | 6¾ | 8⅔ | 6½ |
| 31 | 14½ | 7¼ | 9⅓ | 7 |
| 30 | 15½ | 7¾ | 10 | 7½ |
| 29 | 16¾ | 8¼ | 10⅔ | 8 |
| 28 | 17¾ | 8¾ | 11⅓ | 8½ |
| 27 | 18¾ | 9¼ | 12 | 9 |
| 26 | 19¾ | 10 | 12⅔ | 9½ |
| 25 | 20¾ | 10½ | 13⅓ | 10 |
| 24 | 21¾ | 11 | 14 | 10½ |
| 23 | 23 | 11½ | 14⅔ | 11 |
| 22 | 24 | 12 | 15⅓ | 11½ |
| 21 | 25 | 12½ | 16 | 12 |

## SULFUR FUNGICIDES

Sulfur fungicides can be grouped into two rather specific types or classes, namely: (1) combined sulfur, as calcium, sodium, or potassium sulfides, and (2) uncombined sulfur such as occurs in the wettable sulfur mixtures. In Type 1, the sulfur is rendered soluble by a definite chemical reaction in which complex sulfides are formed. The sulfides are very caustic, highly fungicidal, but very unstable when exposed to the air. When sprayed on a tree they break down to form elemental sulfur; this insures the lasting effectiveness of the spray. In general, they are apt to cause some injury to most types of foliage, and should not be used at all on such tender foliage as peach, plum, and sweet cherry.

Type 2, comprising uncombined sulfur, is prepared as a mechanical mixture in which the sulfur remains insoluble. This type is less effective as a fungicide, but causes practically no injury to any type of foliage that tolerates sulfur.

### *Lime-sulfur*

Lime-sulfur is the most important member of the sulfide group. Practically all commercial brands of the concentrated form are of equal value, provided the Baumé reading is 32-33°. A lime-sulfur having a 30° Baumé reading contains 2.7 pounds of sulfur to a gallon of the concentrate. The sulfur is mostly in the form of penta-sulfides (a maximum combination of sulfur with lime), in which form it is most effective as a fungicide. Lime-sulfurs with lower Baumé readings (which frequently occur in home-made lime-sulfur preparations) are less effective in controlling diseases, and, when combined with arsenicals, are apt to cause injury to foliage.

Liquid lime-sulfur has been the standard spray material for apples for many years. Recently, however, rather severe losses have resulted from its use. The results from recent experiments have shown that not only the foliage is frequently burned and fruit russeted, but also the leaf area is reduced over 25 per cent. Hence, the entire vigor of the tree is reduced which, in turn, affects the set of fruit, and the appearance and quality of the apple. This injury is further increased when lime-sulfur is combined with lead arsenate. It is for these reasons that lime-sulfur should be replaced by safer materials throughout the summer spraying. There are a few reliable substitutes, one of which is the flotation type sulfur.

### *Dry Lime-sulfur*

For greater convenience in handling, shipping, and storing, manufacturers have devised powdered forms of lime-sulfur. Powdered or dry lime-sulfur contains the same ingredients as liquid lime-sulfur and, in addition, a stabilizer, making its manufacture possible. Chemically, 4 pounds of dry lime-sulfur is equivalent in sulfide content to 1 gallon of liquid lime-sulfur concentrate. In practice, the dry form has caused less injury than an equal concentration of the liquid. Since it is safer, and yet equally as effective as liquid lime-sulfur, it is preferred if either is to be used for summer spraying on apples.

### *Other Sulfides of Sulfur*

These are compounds similar to lime-sulfur, except that sodium or potassium is combined with sulfur instead of lime. They are usually sold on the market under trade names, and two of the more generally used are Soluble Sulfur Compound and Sulfocide. A note of warning must be sounded against combining these sulfides with lead arsenate for summer spraying. Such a combination may result in releasing free arsenic, followed with serious burning of the foliage and even defoliation. When such proprietary compounds are used the manufacturers' recommendations should be followed in each case.

### *The Wettable Sulfur Sprays*

Sulfur alone cannot be used to make a spray, because water will not wet it. This difficulty has been overcome by the use of various seasoning or wetting agents. Mixtures of lime and calcium caseinate, or lime and glue, are the more common wetting agents, though such mixtures reduce the fungicidal action of the sulfur. Many manufacturers have developed other types of wetting agents and are producing excellent wettable sulfurs.

Wettable sulfur sprays are practically non-caustic, rarely cause injury to foliage, and little impairment in finish to fruit. While they are ideal from the standpoint of safety, many of them lack efficiency in control, especially of such apple diseases as Brooks spot, blotch, and bitter rot. In sections where these diseases do not occur, a flotation type sulfur will prevent infection of apple scab after the pre-pink stage. Flotation type sulfur and other wettable sulfurs should not be used on peaches in combination with lead arsenate, because of possible foliage and twig injury.

A description of some of the better known wettable sulfur sprays follows. Very little, if any, lime should be added to these sprays on apples. Manufacturers' directions should be followed.

*Flotation Type Sulfur.*—One of the most effective wettable sulfur sprays for the control of apple scab is known as flotation sulfur. It is made from a by-product in the manufacture of artificial gas. It is colloidal in nature, contains a trace of insoluble materials, suspends well in water, and is sold on the market in paste form. Results from four seasons' experiments indicate that the paste form can be depended upon for the control of apple scab during the post-bloom period.

There are several flotation type sulfur products on the market. Discounting the amount of foreign material often found in some of these pastes, they are about equal in effectiveness. They contain around 40 to 50 per cent sulfur and should be used in pre-bloom at 12 pounds to 100 gallons of water, and after bloom 6 to 10 pounds to 100 gallons.

In addition to the regular flotation sulfurs there are a few prepared forms of sulfur pastes that physically resemble the flotation form. The results of one season's field trials indicate that two of these, Ultrafine and Flotox, are just as effective as the regular flotation, and are intended to be included in the flotation type sulfurs recommended in the spray schedules. They are a little higher in sulfur content.

*Other Wettable Sulfur Sprays.*—The following is a partial list of proprietary wettable sulfur compounds: Catalytic, Dritomic, Kolofog, Magnetic, Micronizer, Mike, Mist Brand, Mulsoid, and Sulfuron. While most of these were developed primarily for peach spraying, they have more recently been found satisfactory for apple scab during the post-bloom period or to supplement a weak lime-sulfur. They should be used according to manufacturers' directions or at the strengths suggested in the schedules.

*Home-made Wettable Sulfur.*—A promising wettable sulfur has been made by mixing dry a fine grade of dusting sulfur, 10 pounds; dried skim milk, 8 ounces; and Aresklene (a wetting agent), 1 ounce. In experimental work, this mixture has proved satisfactory, and can be used in the same way and in the same amounts as any of the commercial wettable sulfurs. A considerable saving in cost is the chief advantage.

### *Lime-Sulfur and Dusting Sulfur Combinations*

Heretofore it was considered that the lime-sulfurs could only be combined with a wettable sulfur. In recent tests it has been shown that lime-sulfur is somewhat of a wetting agent for finely ground sulfurs. The method of mixing is important. It is best to mix the dry lime-sulfur and dusting sulfur dry, then make into a thin paste before

adding to the spray tank. In many sprayers a tank mix can be used by adding the dry lime-sulfur to the tank in just enough water so that the agitator paddles reach it. Then sift in the dusting sulfur with agitator running. A 90-10 sulfur-bentonite dusting sulfur is most convenient.

Liquid lime-sulfur also can be used. To mix the liquid lime-sulfur and dusting sulfur place the right amount of sulfur in a pail, then add slowly, while stirring, the undiluted lime-sulfur until a thin paste is obtained. Pour this into the partly filled tank and complete the filling. While these combinations are not as easy to mix as when wettable sulfurs are used, they are just as effective and cost much less.

### Zinc Sulfate

Zinc sulfate has been introduced into the peach spray schedule to prevent arsenical injury. It has been found that it has practically no fungicidal value. Consequently, it is recommended only in the shuck-fall spray and this should be followed in 10 days or 2 weeks by a wettable sulfur spray for the control of scab and brown rot. Powdered zinc sulfate is the recommended form and is sold on the market in three standard grades: namely, 22¼ per cent, 25 per cent, and 36 per cent. The schedule on page 11 is based on the 25 per cent material.

### Bordeaux Mixture

The old standard bordeaux mixtures were prepared with equal weights of copper sulfate and stone (lump) lime. Because of copper injury to foliage and fruit this formula has been changed to include a greater percentage of lime. It has also been found that equally as good bordeaux mixtures can be made with a special fine hydrated spray lime, which is now on the market, as with the stone lime. Hydrated lime is usually more accessible and much less troublesome to use. In all recommendations included in this bulletin, a good grade of *freshly hydrated lime* is specified. A mixture made from 4 pounds of copper sulfate and 8 pounds of hydrated lime to 100 gallons of water is designated by the formula 4-8-100. The proportions are changed according to strength desired.

There are two general methods now in use for preparing bordeaux mixture. The standard method is Method I, prepared as follows:

#### *Method I*

Prepare a stock solution of copper sulfate by dissolving the required amount of copper sulfate in the ratio of 1 pound to 1 gallon of

water. If copper sulfate crystals are used, suspend them in a sack submerged just beneath the surface of the water. The warmer the water, the more rapidly the crystals will dissolve, but they will dissolve in moderately cold water in a few hours. If the powdered form of copper sulfate is used, it will dissolve immediately.

The stock hydrated lime is prepared by making a lime paste of known strength which can be washed into the tank through a screen. If a good grade of freshly hydrated lime is available it may be sifted directly into the tank.

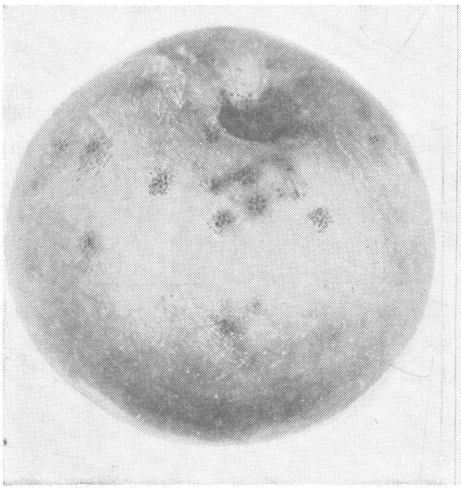

Fig. 11.—Brooks spot

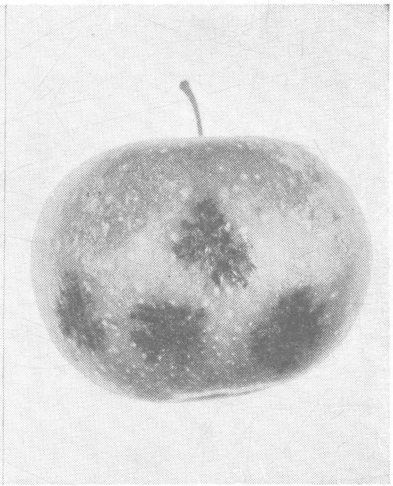

Fig. 12.—Apple blotch

These two diseases are controlled by bordeaux mixture.

To fill a 100-gallon tank with a 4-8-100 bordeaux mixture, fill the tank two-thirds full of water, and start the engine to keep the agitator running. Mix the 8 pounds of hydrated lime into a cream and pour through a strainer into the tank; *when thoroughly mixed* add the 4 gallons of copper sulfate stock solution. Complete the filling of the tank to 100 gallons. If lead arsenate is to be used it should be added last.

### *Method II*

The second method is the preparation of *instant bordeaux mixture,* using the powdered form of copper sulfate which dissolves quickly and no stock solution, therefore, is necessary. The mixture is made as follows: Fill the tank half full with water and, with the agitator running, wash in the hydrated lime through the screen. Next fill the tank two-thirds to three-fourths full, place the powdered cop-

per sulfate on the screen and wash through, and then completely fill the tank.

Bordeaux mixture is not recommended for use in apple orchards in the northern half of Ohio. While it will control scab, it is likely to cause severe injury, especially during cool, damp weather. In the southern part of the state it is recommended for the control of Brooks spot and bitter rot, and on varieties particularly susceptible to blotch.

### Fixed Copper Compounds

Many insoluble copper compounds have been developed as substitutes for bordeaux mixture. In general they are not quite as effective in disease control, but are somewhat less injurious to fruit foliage.

A few of these insoluble coppers that have been tested on fruit in Ohio are: Basic copper chloride (Cupro-K), basic copper sulfate (Basi-Cop), and copper ammonium silicate (Coposil). Since the copper content of these compounds varies, it is suggested that they be used at companies' recommendations. All of these may cause foliage injury and fruit russet on apples if applied before midsummer. They controlled cherry leaf spot better than any other material in 1938 and 1939. One pound of hydrated lime should be used with each pound of copper (based on 25 per cent metallic).

### Nicotine Sprays

Nicotine is the most suitable poison to use against aphids, leafhoppers, and red bugs infesting fruit trees. Nicotine sulfate is the form in which it is purchased. This will combine safely with all of our insecticides and fungicides used in the orchard, though it adds considerably to the expense of these sprays. Nicotine sprays must strike the bodies of insects to kill them, and has very little insecticidal value, except at the time of application. It is useless to apply nicotine for aphids unless the insects are exposed, so that they can be covered with the spray.

When nicotine sulfate is combined with a ¾ per cent oil, the spray has given rather good results in experimental tests against green aphis when applied after the aphis colonies appear on the foliage; however, it cannot be depended upon for controlling green aphis when conditions are favorable for the insect's development. The grower should study his orchard and decide for himself whether the losses from these insects are likely to prove more costly than the use of nicotine spray.

For detailed information concerning different species of apple aphids and methods of control, consult Ohio Experiment Station Bul-

letin No. 464. For information concerning the use of nicotine sulfate against codling moth, see oil and nicotine, page 29.

### Lead Arsenate

Lead arsenate is the most extensively used stomach poison for controlling codling moth and other chewing insects in the orchard. Powdered lead arsenate does not deteriorate with age. It should contain at least 30 per cent of arsenic pentoxide and not over ¾ of 1 per cent of water-soluble arsenic. The manufacture of lead arsenate is well standardized and there is little danger of getting an inferior product.

Lead arsenate has good physical properties for spraying and does not dissolve, but is held in suspension in water. It can be combined with fungicides, such as lime-sulfur or bordeaux mixture, in making a combination spray. Lead arsenate adheres well as a spray, which increases its effectiveness against insects, but this same quality prevents its being ideal for the purpose intended, because of the residue present on harvested fruit. Though many tests have been made with substitute materials, it still takes front rank in the degree of insect control secured in the orchard.

Lead arsenate is best prepared by sifting it slowly into the tank while the agitator is going. On peach foliage, and in the summer applications on apple, good hydrated lime is added to prevent arsenical injury.

### Lead Arsenate and Oil Combined

The combination of lead arsenate and summer oil is now quite generally recommended for use in orchards where the codling moth is severe and where additional applications of lead arsenate sprays have failed to control. It is very effective against codling moth, especially if several applications are made. This is due to the fact that an increased load of lead arsenate is deposited on the fruit, and the deposit is more resistant to weathering.

In "problem" orchards the use of the oil-lead arsenate combination should be limited, if possible, to sprays against the first brood, since its use after this period rapidly builds up dangerous residues, very difficult of removal. *Injury to foliage will occur if oil follows sulfur too closely; therefore, this combination should not be applied until about 2 weeks after a sulfur spray.* A weak bordeaux is the usual fungicide combined with oil-lead arsenate, and this in some cases seems to aid in preventing burning.

Oil may be used at either "sticker" or "ovicidal" strengths. One quart per 100 gallons of spray is sufficient to stick the lead arsenate

to the fruit and foliage, while 3 quarts to 100 gallons gives a definite killing or ovicidal effect against the eggs of the codling moth. When egg laying occurs in definite "peaks" and the spray can be accurately timed, excellent results may be obtained by the ovicidal strength. At "sticker" strength the oil is more effective than any other stickers tried to date. Either hydrated lime or Bordeaux should be used with both strengths of oil. Bordeaux is recommended at 2-4-100 or 1-2-100.

### Lead Arsenate Substitutes

When the problem of arsenical residue came into the foreground there developed an immediate interest in arsenical substitutes. It would be useless to list the materials that have been tried in the hope that they might replace lead arsenate, since almost all of these have been failures. Only those that have given some encouraging results and have been well tested will be discussed.

1. *Non-lead Arsenicals.*—Since these materials do not contain lead, their use would be a great aid in the reduction of lead residue. Because of this, a great deal of time and effort have been expended in developing materials of this character for possible use against the codling moth. In Ohio, calcium arsenate and zinc arsenate have given the best control of those tested. It has been shown, however, that neither of these substitutes is as effective against codling moth as is lead arsenate. Therefore, complete substitution with these materials is out of the question.

However, in areas where there is no third brood of codling moth and where the infestation is not severe, some non-lead arsenicals may be used to good advantage in mid-summer spraying. If these materials are substituted they should be used at the recommendations given, and 8 pounds of lime should be added per 100 gallons of spray.

In tests covering a number of years, calcium arsenate has been found to be about equal in worm control to zinc arsenate. However, if the season is cool and damp, calcium arsenate has shown a decided tendency to burn foliage. This injury is offset by the use of lime as previously noted, but even so, some late defoliation may result. The use of zinc arsenate has not been attended by such injury. Attempts to increase the efficiency of calcium and zinc arsenates by adding stickers, such as soap, oil, and soybean flour, have not been successful due to the increase in foliage injury that has occurred in some seasons.

2. *Oil-Nicotine.*—Experiments and practical use have clearly demonstrated the value of oil-nicotine in codling moth control. This combination leaves no harmful residue but, if applied too soon after

lead arsenate, the latter may be "sealed" on the fruit by the action of the oil. For a short time after application it is very toxic to insects; hence, the more numerous the applications, the more effective it becomes, especially against unsightly codling moth stings. Although certain varieties of apples are occasionally spotted by summer oil it usually leaves the fruit with good finish and free from objectionable residue.

The use of oil-nicotine against second and third brood worms should be seriously considered in "problem" orchards by growers not prepared to wash. On the other hand, the material is expensive and is difficult to combine with a satisfactory fungicide. The formula suggested under Ohio conditions is: summer oil 3 quarts, nicotine sulfate ¾ pint, water 100 gallons. Sulfur fungicide cannot be combined with this. Neither should the oil-nicotine immediately follow a sulfur fungicide application.

Oil-nicotine should *not* be confused with "fixed nicotines." The latter are being tested, and, while showing promise, sufficient data have not been collected as yet to justify their recommendation.

*Materials Not Recommended.*—Under Ohio conditions the following materials are *not* recommended for use in the orchard against codling moth: Natural cryolite, synthetic cryolite, barium fluosilicate, Pyrethrum, Derris or Rotenone, and Penothiazine. Likewise, summer oils are not recommended unless fortified with lead arsenate, or nicotine.

## Suggestions Concerning Spray Practices

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### PROTECTING THE FRUIT

#### The Problem of Spray Residue

Where apple trees are thoroughly sprayed with one or more applications of lead arsenate after July 1, the amount of residue may exceed the present tolerance. These tolerances, as established by the Federal Food and Drug Administration for 1939, were 0.025 grain of lead, 0.01 grain of arsenic trioxide ($As_2O_3$) and 0.01 grain of fluorine per pound of fruit.

In orchards where the spray schedule requires the use of lead arsenate late in the season, the residue may be reduced within the tolerance by washing the fruit in a weak solution of hydrochloric acid. For detailed information concerning the Removal of Spray Residue the reader is directed to Bulletin 584, Ohio Experiment Station, Wooster, Ohio.

*Cleaning the Fruit.*—It has been demonstrated that apples having relatively heavy deposits of residue, frequently as much as 8 or 10 times the present tolerances, may be satisfactorily cleaned by washing in the underbrush flood type of washer. The flotation types of washers, while not quite so efficient as the underbrush flood type, have generally been satisfactory under Ohio conditions.

The mechanical brush cleaners cannot be depended upon for the removal of more than 25 per cent of the total residue and are not recommended for this purpose.

Successful washers have not yet appeared on the market for the removal of residue from grapes that have been sprayed for the control of berry-moth. Until such washers have been developed, the grape spray schedule will of necessity have to be curtailed so as to enable the harvested fruit to be marketed with the least possible residue.

## Spray and Weather Injury

Spray and weather injury may be very similar in appearance and frequently it is necessary to examine an unsprayed tree before the correct amount of spray injury may be determined. Spray injury develops when improper materials have been used, or when the right materials have been applied in the wrong way, or when weather favors injury. Weather injury may result from exposures to extremes of temperature or moisture. Varieties vary greatly in their susceptibility to spray and weather injuries (see page 10).

Trees lacking vigor are injured frequently by spray and weather conditions, whereas vigorous trees would not be affected so easily. Similarly, foliage that has been injured previously by insects, diseases, hail or wind whipping, is more susceptible to spray injury than healthy foliage. Accordingly, orchards which are maintained in a healthy condition are injured less frequently by spray materials or adverse weather conditions.

*Bordeaux Injury.*—Bordeaux mixture sprays on apples may injure the fruit in the form of russeting. Varieties such as Grimes, Golden Delicious, Jonathan, Baldwin, Ben Davis, Gano, and Ensee are very susceptible to russet injury. Other varieties such as Rome, Gallia Beauty, Delicious, Northwestern Greening, Duchess, and Wealthy are comparatively resistant to russet injury. Applications of bordeaux in the pre-blossom, petal-fall and 10-day sprays cause the most russeting, and the chances for russeting continue until about six weeks after petal-fall. Bordeaux injury is increased by the slow drying of sprays, and cool, wet weather with high relative humidity. The safest time to spray is when trees are dry and the weather favors quick drying of

the spray material on the trees. High temperatures do not induce bordeaux injury, but tend to reduce it.

Bordeaux injures apple foliage by causing yellowing of the leaves and in many cases premature defoliation. This injury is reduced by using a weak bordeaux such as 2-4-100. Stronger bordeaux should not be used unless needed for control of such diseases as bitter rot.

*Lime-sulfur Injury.*—Lime sulfur will burn both foliage and small apples if the spray is applied during very hot weather, or in strong concentrations, or under weather conditions resulting in slow drying of sprays. It burns the edges of leaves where the material accumulates.

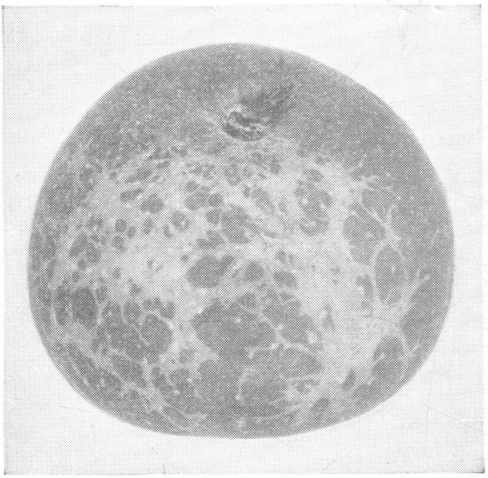

Fig. 13.—Lime-sulfur spray injury on Baldwin apple.

Liquid lime-sulfur often causes dwarfing and crimping of apple leaves in the early stages of their development. This reduces leaf area, affects the proper growth of the fruit, and impairs finish and quality. The extent of this injury may not be noticed, except when there is an actual basis of comparison, as occurs in spray plots where different materials are used in the same orchard.

Foliage dwarfing and crimping also result from low temperatures in early stages of leaf development. This is similar to lime-sulfur injury, and is often confused with it. Spraying whenever the temperature is above 85° F. in the shade, or when the relative humidity is very high frequently produces burning. The slow drying of sprays in cool, cloudy weather increases injury.

The prevention and reduction of lime-sulfur injury can best be secured by substituting dry lime-sulfur, or wettable sulfur, for liquid lime-sulfur, and by adding an excess of lime in the mixture as recommended in the spray program, pages 6 to 8.

Lime-sulfur, either liquid or dry, is not safe for the summer spraying of peach trees. Materials less likely to burn are recommended in the peach spray program.

*Arsenical Injury.*—Peaches are very susceptible to arsenical injury when lead arsenate is used alone or combined with sulfur fungi-

cides that do not contain a sufficient amount of fresh, hydrated lime in the mixture. The leaves are damaged in two ways: (1) They may show many small injured areas, giving a "shot hole" appearance, or (2) they may yellow and drop prematurely, or both. Frequently, tender growing peach twigs are injured in spots where the spray material has accumulated. As the wood ages, scaly bark may develop from this injury. While the fruit is not often directly injured, the damage to foliage may so seriously reduce the manufacture of food that the fruit will be small, of poor color and quality, and may drop prematurely.

To prevent arsenical injury on peaches use the minimum number of lead arsenate applications, and not any more lead arsenate than recommended in the peach spray program (page 11). One application of lead arsenate, combined with zinc sulfate and lime, or with excess lime as recommended in the shuck-fall spray, is sufficient for curculio control in most orchards.

Apple foliage and fruit may be injured by arsenical sprays. The damage to the foliage may be manifest in two ways. The first and more noticeable type is marginal foliage burning, which probably is the result of heavy concentrations of spray materials which collect at the tips and margins of leaves. The second type of injury is a yellowing of the foliage, which may be caused by the absorption of the arsenic by the leaf or by injury to the petiole. In extreme cases of burning the damage may amount to almost total defoliation of the tree.

The shedding of blossoms and newly set fruits, which in some instances has been serious, is another form of injury from lead arsenate, lime-sulfur sprays. Arsenical injury to the fruit is usually expressed by a blackened area around the calyx end, which later becomes sunken. Secondary rot infections of the fruit may follow such injuries.

Arsenical burning on apples is largely prevented by the addition of excess lime to the lead arsenate, lime-sulfur combination. While present evidence indicates that excess lime tends to decrease the efficiency of both the fungicide and the arsenical, the finish of fruit produced when excess lime is added is superior to that produced when the lime is omitted.

*Mechanical Injuries.*—Mechanical injury to the foliage and fruit comes from the improper use of spray equipment, poor break-up of the liquid, coarse particles in the spray material, and drenching of the foliage. It appears in the form of russeted fruit, dwarfed or torn leaves, and in part accounts for the lack of finish and quality of fruit in many orchards. Prevention of these injuries may be secured by following the recommended spraying methods.

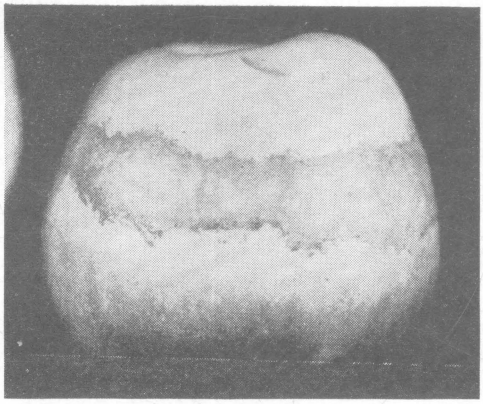

Fig. 14.—Russet ring caused by frost, when apple was very small.

*Weather Injury.*—Weather injury to fruit and foliage is often confused with spray injury. Low temperatures and frosts during the blossoming period and early part of the growing season may cause varying amounts and kinds of russet injury. Often this injury takes the form of a belt of russet around the apple (see Fig. 14).

Leaves may be injured by frost so that dwarfing and crimping develops, and, when severely injured, blisters may develop on the under surfaces. Leaves so injured often turn yellow and drop prematurely.

Extremely hot weather sometimes causes sunburn on the fruit. This is manifested by a discoloration and in extreme cases by a blistering and cracking of the skin on the exposed area. Very hot weather may also cause a bronzing of the red tones and a whitening of the green color tones of the fruit.

## Use of Proper Lime Important in Preventing Spray Injury

The chief use of lime in the summer sprays is to prevent spray injury. Lime also aids the spray operator to see when foliage is thoroughly covered. There are several common forms of lime on the market, therefore fruit growers should use care in purchasing the proper compound. When limestone is burned, the product produced is burned lime (CaO or MgO), sometimes called lump, stone, or quick lime. If water is added to burned lime, hydrated lime is formed. If hydrated lime is exposed to the air, air-slaked lime or carbonated lime is formed. This last product is very inactive and is not suitable for spraying purposes. Hydrated lime is recommended for spraying.

Hydrated lime has several characteristics which the grower should investigate before buying. First, it should be free from grit and so finely divided that 99 per cent of the particles will pass through a 325-mesh sieve; all should pass through a 300-mesh. Second, the lime should be freshly hydrated before it is shipped. Lime kept over 90 days should not be used for spraying purposes. Such lime may be

profitably added to the soil. A supply of lime purchased in the spring will be satisfactory for that season.

### Use of Spreaders

Extensive data taken in many experiments show that very little is gained by the use of spreaders in tree sprays. Spreaders usually make the sprayed tree look somewhat better in that the spray coat is more even. They are reported to make a given amount of spray cover more trees, but this gain is usually offset by the additional cost of the spreader.

In almost all instances spreaders are not to be recommended, except for grapes, where either a soap or fish-oil spreader has proved valuable for the control of berry-moth.

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## AMOUNT OF SPRAY REQUIRED FOR COVERAGE

The amount of spray solution required to properly spray a tree of a given size depends upon a number of variable factors, such as: type of gun or nozzle, volume and pressure developed by the spray pump, velocity and direction of the wind, type of pruning practiced, and the nature and abundance of diseases and insects; more than anything else, however, it depends on the judgment of the individual operating the rod or gun. To spray until a tree drips is not a safe guide to follow. Such a rule may lead to wastefulness, but more often to inadequately spraying a tree.

Growers are cautioned when changing from one type of discharge nozzle to another or from one rate of pressure or volume to either a higher or lower to make sure that they are securing proper coverage.

Records of spray solution required in the Experiment Station orchards have been kept over a long period of years. During this time the spraying was done under the direction of the same man. The sprayers used have been of moderate capacity ranging from 15 to 35 gallons per minute, and carrying pressures of 375 pounds or more. In these orchards trees less than 12 years of age were pruned in such a manner as to leave them moderately dense, while the trees of full bearing age were more openly pruned.

The data submitted in the tables following are taken from the spraying records in those orchards. The amounts of material per tree used at Wooster have at all times corresponded very closely with the amounts used in the orchards of the various sub-stations and county experiment farms. The figures given are not intended as arbitrary recommendations to be followed in every case, but suggestive of the amounts found necessary for good results under the conditions previously mentioned.

GALLONS OF SPRAY SOLUTION APPLIED PER TREE *(Wooster)*

| Age of Trees | Average Amount per Application for Season, in Gallons | | | |
|---|---|---|---|---|
| | Apples | Peaches | Cherries Sour | Cherries Sweet |
| 2 to 3 years | .5 | .7 | | |
| 5 years | 1.5 | 3.0 | | |
| 10 years | 6.0 | 5.4 | | |
| 12 years | 8.0 | | | |
| 15 to 20 years | 10 to 16 | | 7 | 10 |
| 21 to 35 years | 16 to 30 | | | |

## SEASONAL DISTRIBUTION OF SPRAY SOLUTION

The seasonal distribution of the amount of spray solution used in two of the apple orchards at the Experiment Station for a 3-year period is shown in the accompanying table. One orchard was planted in 1893 and the other in 1922.

*Percentage of Total Distribution of Spray Solution Per Year, Over a 3-Year Period*

| | Period ☞ | 1937 | | 1936 | | 1935 | |
|---|---|---|---|---|---|---|---|
| | | Age of Trees | | Age of Trees | | Age of Trees | |
| | | 45 yrs | 16 yrs. | 44 yrs. | 15 yrs. | 43 yrs. | 14 yrs. |
| Pre-Bloom | Dormant | 11 | 13 | 9 | 12 | 10 | 9 |
| | Pre-bloom 1 | 9 | 12 | 10 | 11 | 9 | 9 |
| | Pre-bloom 2 | 10 | 11 | 10 | 12 | 12 | 10 |
| | Pre-bloom 3 | 9 | 11 | | | | 11 |
| | Pre-bloom 4 | 12 | 11 | 10 | 11 | 14 | 11 |
| | Before bloom, per cent | 51 | 58 | 39 | 46 | 45 | 50 |
| After Bloom | Calyx cup | 12 | 13 | 16 | 15 | 14 | 12 |
| | First cover | 13 | 14 | 15 | 16 | 14 | 12 |
| | Second cover | 12 | 15 | 14 | 23 | 13 | 12 |
| | Third cover | 12 | | 16 | | 14 | 14 |
| | After bloom, per cent | 49 | 42 | 61 | 54 | 55 | 50 |

## ESTIMATE OF MATERIALS FOR SEASON

In ordering materials for any season, the first consideration should be to determine as nearly as possible the program to be followed, especially during the early part of the year—the number of sprays, the materials to be used, and the dilution. Then, by using the amounts applied per tree as shown in the table at top of page, it is relatively easy to calculate the amount of material needed to spray a given number of trees.

## DEFINITE PROCEDURE IN SPRAYING

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### Methods of Spray Application

The most important factor in getting a spraying job well done is the sprayman himself. He must start each needed application on time, finish on time, and use equipment and methods skillfully so that each tree is thoroughly sprayed inside and out, top to bottom, with finely broken spray fog, applied to give safe, uniform coverage. There is no substitute for a skilful, alert, thorough working sprayman.

It is relatively easy to get a good spray job with small trees. With trees about 15 feet, the tops, and especially the top centers, are difficult to cover. With trees 20 feet or higher it is rare to find a sprayman giving thorough coverage to the upper third and top center of the trees. Scab and worms too often tell the sad story of failure to spray thoroughly the upper third of the tree.

Multiple cluster nozzles or fog drive brooms may not place enough spray material in the tops, which can often be covered best with single or double nozzle spray guns. A tower on the rig is often needed to get a good job on tree tops when spraying from a moving machine. Lower the tops of any trees too tall to spray thoroughly.

Spray fog must be driven over the tops of mature trees to cover the top center. To secure this the sprayman must carry the up-stroke high enough to see the top of the tree below the spray fog drive. Timely, speedy applications directed from the outside to cover the upper surfaces of expanding leaves and blossoms is most needed in early season scab sprays. For control of such pests as codling moth, bitter rot, Brooks fruit spot and blotch, the cover sprays applied when trees are in full leaf and relatively dense should be applied all around the apples. This often necessitates supplementing usual outside spraying with spraying from the ground underneath the branches, directing spray fog out and up at all angles to cover thoroughly all surfaces of fruit in the interior of the tree.

In spraying demonstrations conducted by the Extension Service, brown or black sponge rubber balls of 2- to 3-inch diameter, stuck on wire hooks, hung in different parts of typical trees and taken down for observation after the spray had dried, were found helpful in studying type of coverage actually secured in different parts of the tree from the different methods and combinations of equipment. Any grower can use this convenient, inexpensive check-up to study the coverage he is getting in his own orchard.

With satisfactory working pressure, fog drive guns or brooms in good order have given no mechanical injury when fruit and foliage was sprayed almost to the orifice of the nozzles. Single nozzle guns on the wide fog adjustment were usually found safe to within 3 to 5 feet

of the nozzle, but when wide open to get distance or height were seldom safe closer than 10 to 15 feet from the nozzle. An alert sprayman with spray fog sense is absolutely necessary to operate single nozzle guns safely without risk from mechanical injury. Yet the single nozzle gun has its place when tall trees are sprayed from the ground, and for spraying the tops of tall trees from the tower on a portable sprayer.

The actual spray application methods used must be worked out to fit the needs of each orchard. The results will soon tell the grower whether the method he uses can be improved upon. Spraying from the top of portable rigs where practicable is most convenient for the sprayman, and permits use of broom and gun combinations that take the capacity of the larger pumps, giving the sprayman more gallons per minute to handle than any other method. Yet it has marked disadvantages in working against wind, especially with fog drive brooms and over soft ground early in the season. Also it is often difficult to secure satisfactory penetration from all angles and thoroughly spray the interior of the trees.

Tank spraying has given best results when it has been completed on time for control of such diseases as apple scab and cherry leaf spot, and has given less satisfactory results in the control of such troubles as codling moth, scale, red mite, aphis, flea-weevil, bitter rot, Brooks fruit spot, and blotch.

Combinations of tank and ground spraying are often effective. Excellent coverage of mature trees is being secured with ground spraying when guns of sufficient capacity are used for top spraying. This method is still widely used with many portable sprayers and with the stationary systems.

Many difficulties are encountered when growers insist on only "spraying with the wind," because often the orchard is not completely sprayed within the necessary time interval for best control of pests. Applications must be completed on time and methods employed that secure prompt complete coverage. Commercial apple orchards in Ohio should use equipment and methods that provide for a complete application in three days or less, especially for apple scab sprays. Occasionally a critical scab spray must be applied in about 24 hours' time for best control.

## Selecting the Sprayer and Equipment

*Size of Pump.*—To determine size of spray pump for the job, figure gallonage requirements for one application (see table, pg. 39) and secure pump with sufficient gallons per minute capacity to apply the spray solution in three working days or less. Keep in mind time needed to refill sprayer and allow for emergencies. Convenient water supplies, orchard filling stations, or hauling water to sprayer promotes

the most efficient use of portable spray pumps. Stationary spray pump installations permit almost continuous use of spray pump capacity. Portable sprayers seldom deliver on the trees more than half the rated pump capacity in a day's time, due to delays and inefficiencies.

Select tanks for portable rigs as large as can be pulled to advantage to save time in refilling. With power take-off rigs, be sure sufficient reserve power is available in tractor above that necessary to pull filled sprayer over most difficult areas, to provide sufficient horsepower according to manufacturers' specifications to drive pump efficiently. The following table is roughly suggestive of pump sizes needed for various sized orchard requirements. In addition use spray pump manufacturers' suggestions on requirements.

*Size of Pumps Needed for Given Quantities of Spray*

| Spray material required for one application | Pump size required in gallons per minute on portable rigs |
|---|---|
| Less than 500 gallons..... | Hand pumps |
| 500 to 3000 gallons..... | Power pumps rated up to 10 gallons |
| 3000 to 6000 gallons..... | Power pumps rated at 12-15 gallons |
| 6000 to 10,000 gallons..... | Power pumps rated at 15-22 gallons |
| Above 10,000 gallons..... | Power pumps rated at 35 gallons or more according to need |

Check up your pump occasionally to determine gallons per minute actually delivered through hose and nozzles. Spraying into a large open head drum of 50-gallon capacity or larger for a given period, such as one minute, and measuring discharge with gauge stick previously notched in gallons, is helpful for check-up work. Time required to empty tank also tells you gallons per minute discharged. Many rigs, especially after some use, are found to deliver far less than the rated pump capacity, and need attention to valves, packing, leaks, etc. Sometimes restrictions in pipe lines, and size or condition of hose or fittings, or use of nozzles with too small disks prevent discharge of pump capacity. Keep your pump efficient.

*Pressure.*—Pressure at nozzles of 350 pounds or more on power rigs has given finest break-up of spray fog and most economical coverage. Pressure of 600 pounds or more gives splendid coverage. High pressures are limited only by added power costs and ability of hose and equipment to withstand the higher pressures. With fine fog break-up the higher pressures have given least mechanical injury and most satisfactory coverage for the gallons applied.

Many pressure gauges, especially the older ones, have been found inaccurate in the orchard. Over 60 per cent of the gauges checked at work in Ohio orchards registered incorrectly. often indicating 200 pounds or more pressure than was actually carried in the hose line. Some county agents have calibrated gauges to assist growers in check-

ing their pressure gauges for accuracy, and adjusting pressure regulator to carry pressure desired.

*Capacity of Spray Guns.*—There is a place for both single guns and multiple fog-drive guns or brooms. Combinations of both are often effective, using the single gun for treetops and where thorough coverage with brooms is difficult or impossible.

*Capacity of Single Nozzle Spray Guns in Gallons per Minute*

| Pounds pressure | Diameter of discs—Fraction of inch | | | | | |
|---|---|---|---|---|---|---|
| | 3/64 | 5/64 | 3/32 | 7/64 | 1/8 | 11/64 |
| 300 | 1.1 | 2.4 | 2.7 | 4.3 | 5.6 | 9.4 |
| 400 | 1.2 | 2.7 | 3.0 | 4.8 | 6.3 | 10.9 |
| 500 | 1.3 | 3.0 | 3.3 | 5.3 | 7.0 | 12.3 |
| 600 | 1.4 | 3.2 | 3.5 | 5.7 | 7.7 | 13.6 |

*Capacity of "Fog-Drive" Guns in Gallons per Minute*

Total discharge capacities of fog-drive guns which are regularly equipped with discs with 4/64 inch diameter holes.

| Pounds pressure | 3 Nozzles | 4 Nozzles | 6 Nozzles | 8 Nozzles |
|---|---|---|---|---|
| 300 | 4.1 | 5.5 | 8.2 | 11.0 |
| 400 | 4.7 | 6.3 | 9.5 | 12.6 |
| 500 | 5.4 | 7.2 | 10.8 | 14.3 |
| 600 | 5.9 | 7 9 | 11.9 | 15.9 |

5/64" discs give ⅓ more capacity and 3/64" discs give ⅓ less capacity than is indicated in the above chart.

Since sprayers are purchased to put a needed number of gallons on your orchard in a given time, see that combinations of nozzles used permit efficient discharge of the rated capacity of your spray pump. See that the parts of nozzles that soon wear, such as discs and whirl plates, are replaced as necessary. Wornout nozzles and a disc too large for the eddy chamber of the nozzle result in coarse wasteful sprays.

For ground spraying, single or double nozzle guns and fog-drive brooms up to 6 nozzles can be used. Higher pressure pumps of large capacity are now permitting smaller, lighter hose for ground spraying, such as ⅜-inch. It is not necessary to use larger than ½-inch hose for ground spraying. The shortest length of hose for ground spraying should be 50 feet and many use up to 100 feet or more for hillside spraying and for stationary plant work. For tank spraying, hose should be as short as it is convenient to handle, and large enough to carry capacity of the fog-drive broom used. Usually short lengths of ¾-inch hose are used for tank spraying with brooms of 8 nozzles or more. A swivel that does not leak is a handy device to place between gun and hose to prevent twisting and kinking of the hose.

## Water Supply System

A water supply system, set up so that the sprayer can be filled quickly and so that there will be only a short haul, is necessary. Locate supply tanks in the center of each 20-acre block of orchard. In most cases the water can be pumped at the source of supply into one tank, and piped from there by gravity to supply tanks located at convenient points. All tanks should be set up so that they serve as overhead filling stations with a large 2- to 4-inch discharge pipe equipped with a gate valve for quickly filling the sprayer. Such an arrangement greatly speeds up the work of spraying and, according to cost records at the Ohio Agricultural Experiment Station, reduces the cost materially.

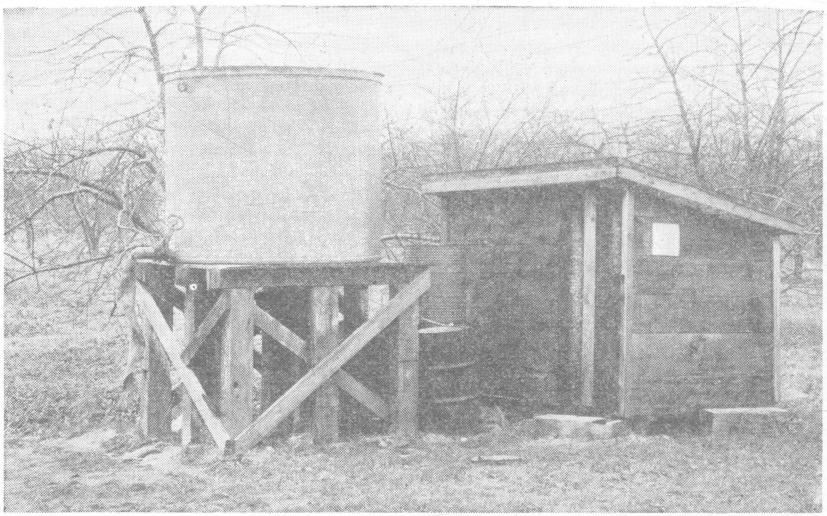

Fig. 15.—Conveniently located filling stations save much time in spraying.

Where a pond or stream is used as a water supply, a tank filler helps in filling the sprayer quickly. In some cases, supply wagons or trucks are used to haul water from the sources of supply to the sprayer. This requires extra teams or trucks, but is a method which probably enables the grower to secure the most efficient use of his sprayer.

## Care of the Sprayer

The proper care of the sprayer does much to increase its useful life. At the end of each day's spraying, water should be pumped through the spray pump, hose, and nozzles to clean out all chemicals. At the close of the spraying season, the pump, hose, and all equipment should be thoroughly cleaned with water and drained. Then the hose, rods, and guns should be taken off the sprayer and looked over carefully, and any needed repairs made. Nozzles should be cleaned and

oiled. The pump should be filled with oil and parts apt to corrode should be cleaned and coated with grease before the rig is put away for the winter.

### Equipment for Night Spraying

High winds and occasionally high temperatures during the day often interfere with proper application of sprays and dusts. The time may be so limited that the equipment at hand is inadequate to cover the orchard in the required time, working only during the day. Since the wind actually dies down about nightfall, conditions at night are generally more favorable for spraying and dusting than during the day. However, on occasional nights the humidity is so high and the rate of drying of the spray so slow that the spray may not dry until morning. Under these conditions very severe burning and russeting of foliage and fruit may occur. Where spraying is done at night the operator should make certain that the spray is drying on the trees in a moderate length of time.

Night applications are limited to situations where the operator rides the moving spray tank or duster. In order to spray at night a light must be provided on the sprayer. A single electric headlight bulb attached to the top of a pole, elevated above the operator's head at about the center of the spray machine, has been found to give the most satisfactory lighting for night spraying. Electricity may be supplied by an ordinary storage battery, charged with an automobile generator operated by the sprayer engine or by the tractor drawing the sprayer.

### Stationary Spray Plants

Stationary spray plants are rapidly gaining favor with many growers. With the stationary system, the spray solution is pumped from one central plant through pipes to all parts of the orchard. Only one power plant is needed. In a modified system the spray plant is portable and can be moved from one pipe system to another.

Some advantages of the stationary system are: (1) It eliminates use of wheeled trucks, and tractors, thereby preventing the compacting and subsequent eroding of the soil; (2) there is less wear and tear on machinery than where portable sprayers are used; (3) the cost of transporting liquid through the orchard is less through pipe line than by hauling; (4) it obviates loss of time in refilling portable tanks; (5) it allows the spraying to be done promptly, regardless of soil conditions; (6) all spraying must be done from the ground, which is conducive to a more thorough job of spray coverage.

Some disadvantages of the stationary system are: (1) High first cost of installation; (2) interference of pipe lines with other operations; (3) inability to spray at night; and (4) the harder physical

labor involved in dragging a longer length of hose on the ground, than that of spraying from the top of a movable rig. With high pressure pumps and the use of lighter ⅜-inch hose this latter difficulty is greatly reduced. Further information may be obtained by sending for Ohio Exp. Station Bul. 572.

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## Dusting

*Apples.*—Dusting apples for controlling insects and diseases has been thoroughly tested in Ohio and has very limited application. It will frequently suffice when the orchard is coming into bearing, but in bearing orchards dusting of apples and pears is now limited to supplementary applications. If a dusting program is followed for control of curculio and codling moth, from five to seven post-blossom applications will be necessary in most seasons.

*Other Fruits.*—Dusting of peaches, plums, and sweet cherries for control of brown rot has produced good results and is a method highly recommended where the application is properly timed. An 80-10-10 sulfur-lime-lead-arsenate dust, or, in the absence of fungus, 90-10 lime-lead arsenate dust is recommended for early applications where curculio control is important. For later applications a 90-10 sulfur-lime mixture is preferred.

Dusting of grapes has very limited application, and thus far is recommended only for leafhopper control where a nicotine spray cannot be applied. To be successful in dusting for grape leafhoppers, one should use a nicotine dust carrying sufficient nicotine to kill the insects. If the leafhoppers are merely dislodged from the foliage many will resume feeding in a short time. Dusting for the prevention of grape root-worm and berry-moth injury has not proved satisfactory.

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## Troubles Combated by Methods Other Than Spraying

### Fire Blight

Blossom blight, which is one form of fire blight, is most severe throughout southern Ohio. In northern Ohio vigorously growing trees of susceptible varieties are sometimes attacked by blossom blight, but are more likely to be infected with twig blight, which is another manifestation of the same disease. Extremely susceptible varieties, like Tompkin's County King, develop limb and body cankers if the disease is permitted to spread unchecked.

In southern Ohio spraying with 2-6-100 bordeaux mixture in full bloom has been practiced by some growers for a number of years. While this application reduces the amount of blossom blight, it may cause some russeting of the fruit. Where blossom blight is a perpetual

problem, it is suggested that a bordeaux spray be applied when one-third of the blossoms have opened. Lead arsenate should not be included with this spray. Cutting out of blossom blight is not advised.

Twig blight may be checked in the northern part of the state by removing all blighted twigs and painting body cankers during September and October. At that season of the year it is not necessary to use a disinfectant on the pruning tools.

*Fire Blight Canker Solution.*—To 3 ounces of concentrated hydrochloric acid add 1 quart of hot water in an enamel kettle, and in this mixture dissolve 9 pounds of dry zinc chloride powder. Commercial grades of chemicals are satisfactory for this solution. Add sufficient red or blue coloring, using a dye such as the Diamond brand, easily secured from local drug store, so that areas treated can be checked for thorough work. After cooling, pour the above solution into 7 pints of denatured alcohol and mix thoroughly.

Store in tightly stoppered large glass bottles or jugs to prevent evaporation. Apply with small paint brush.

If blight is cut out in the spring of the year, or during the summer, a disinfectant made by dissolving two tablets of bichloride of mercury and two tablets of cyanide of mercury in one quart of water should be used. A rag or sponge tied to the end of a stick makes a convenient swab for the larger pruning shears or saw. This mixture should be carried in a glass or wooden vessel. *It is extremely poisonous and should be kept out of the reach of children and livestock.*

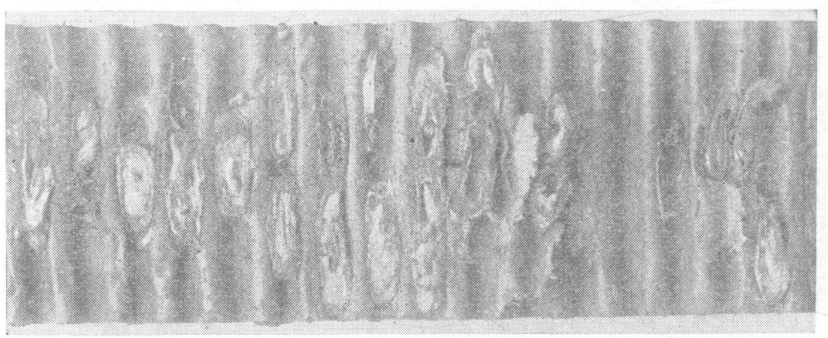

Fig. 16.—Codling moth cocoons under corrugated paper band.

## Codling Moth Bands, Chemically Treated

In orchards where codling moth is a serious problem, growers have found chemically treated tree bands a valuable aid in reducing the worm population. These bands consist of strips of single faced corrugated paper, cut 2 inches wide, and which have been dipped in a solution of beta-naphthol dissolved in oil. This results in the paper

taking up much of the chemical which is toxic to insect larvae, but does not harm the mature tree.

*Young trees with smooth bark should not be banded.*

When old trees are banded, the trunk and lower limbs are scraped to remove all loose bark. This scraping should extend up about 10 feet. A special tool for scraping, such as a box scraper, or even a short handled hoe, is desirable.

The chemically treated band is then wound tightly around the tree trunk and fastened with large headed roofing nails or special wire staples (see Fig. 17). Care must be taken to fit the band into the depressions of the trunk.

Fig. 17.—Chemically treated band on tree trunk kills the larvae which go under it to transform.

The bands should be applied just before the larvae of the first brood leave the apples. It is these worms that must be killed before they transform to moths. The bands should be in place in southern Ohio by June 1, in central Ohio by June 8, and in northern Ohio by June 15. Since the bands, when applied, slowly lose their toxicity, they should not be made up or placed on the trees long before the above dates.

When the larvae, after leaving the apple, search for a place to spin their cocoons, they find the paper band and spin up in the corrugations and in the grooves of the paper held tightly against the tree (see Fig. 16). If the bands are properly made, the worms will be killed during June or July within a few days after they go under them. By autumn the bands have lost much of their toxicity and do not kill all of the larvae. These, however, are affected by the chemical and usually die during hibernation. The bands are serviceable only for one season, and should be taken off the trees early in December and burned.

It is estimated that on a well scraped tree the bands catch from 40 to 50 per cent of the worms which leave the apples. Their use should make it much easier to control with sprays, though the bands do not make it possible to eliminate any sprays. They are recommended only in orchards where the spray program has failed to control the codling moth satisfactorily.

### *Reducing Codling Moth Losses by Orchard and Packing House Sanitation*

Orchard sanitation is important as a method of reducing codling moth losses. This includes: (a) elimination of hibernating places such as piles of wood, cut trees, or other debris on the ground, and (b) the prompt disposal of wormy apples. While a sod mulch or cover crop is not utilized freely as a cocooning place, a mulch consisting of cornstalks or coarse weeds will shelter many transforming larvae.

Thinning operations afford an opportunity to remove from the orchard apples containing first brood larvae. Prompt gathering of worm infested dropped apples and burying them or otherwise disposing of the same, prevent these worms from adding to the overwintering population.

Packing house sanitation is very important in orchards where the codling moth is a serious problem. The larvae leave the apples in the packing house or storage rooms, and crawl into cracks and crevices and into the joints of the apple crates. These moths, if allowed to escape, would cause worm-infested fruit within several tree rows of the packing house.

Packing houses and rooms where picking crates are stored should be tightly screened or otherwise kept closed during early summer until all of the moths have emerged and died.

## Cedar Rust

Cedar rust has become increasingly prevalent on Rome Beauties in southern Ohio. This is a disease that varies a great deal from season to season, and from locality to locality. The reason for this variation is due either to the lack, or abundance, of rainfall during the latter part of May and early June in the different localities.

Spores, which infect apple trees, are produced on the cedar trees during rainy periods and are blown by the wind to apple trees, where they cause infection on the leaves and fruit. Records have been obtained where cedar rust spores have been blown for a distance of 5 miles and produced infection. However, severe infection usually is not accomplished unless the cedar trees are within 3 miles of the orchard. Infection will be more severe when the cedar trees are located near the orchards.

Varietal susceptibility varies greatly, as indicated in the chart on page 10. Rome Beauty, Jonathan, and Delicious are some of the more susceptible varieties grown in southern Ohio.

This disease is very difficult and expensive to control by spraying. If the cedar trees are removed the disease is no longer a factor.

## Protecting Against Climbing Cutworms

Opening buds of grapes and newly expanded leaves and blossom buds of apple are often devoured in April or early May by climbing cutworms. These feed only at night, and hide under trash on the soil during the day. Unless the grower is keeping close watch, many fruit buds may be devoured, or even an entire crop of grapes destroyed, before the presence of the insect is discovered (see Fig. 18).

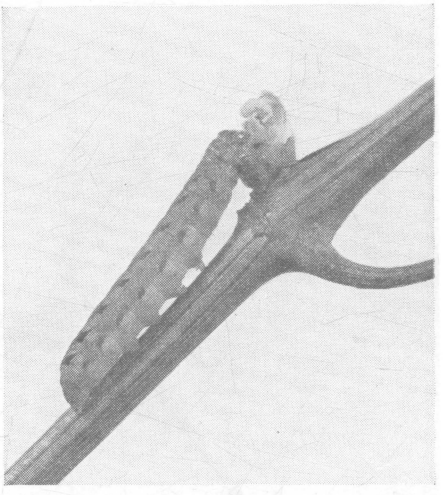

Fig. 18.—The climbing cutworm feeding on grape bud.

Application of a narrow band of sticky tree-tanglefoot on the trunks of fruit trees, and beneath the bottom wire on grape canes and posts in vineyards, will put a stop to this damage. The application should be made as soon as the worms are discovered. They are unable to cross such a band to reach the succulent buds. Many can be killed by scattering poisoned bran mash bait on the ground. The poisoned bait is dependable only where the tanglefoot has been previously applied to prevent their ascent. While applications of lead arsenate in the pre-blossom spray on apples fails to control, it has been observed that spraying with fluorine spray, as given in the note on page 6 for apple flea weevil, is a satisfactory method.

## Peach Tree Borers

### *Gas Treatment for Borers Located at or beneath Ground Surface*

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### *Paradichlorobenzene*

This chemical, sometimes called P. D. B., Paracide, and by other trade names as well, is now widely used to control the peach tree borer located at or just beneath the ground surface. This material is sold as finely granulated crystals.

*Directions for Using Crystal-ring Method.*—One ounce of the chemical is advised for treating a full grown tree and from ½ to ¾ ounce on trees from three to five years old, depending upon the size of the trees. Not more than 1½ ounces should be used in any case. Trees less than three years of age can be treated only with the risk of some injury by the chemical.

1.—Apply in the latter half of September or early October when the soil is dry. This will kill the borers while young, and after all eggs are hatched. The temperature of the soil at time of application should be above 55°F. for best results. If fall treatment has not been made and the life of the tree is threatened, a spring application can be made as soon as the soil temperature becomes high enough. This is usually about May 15. At lower temperatures, the ethylene dichloride emulsion treatment is preferred.

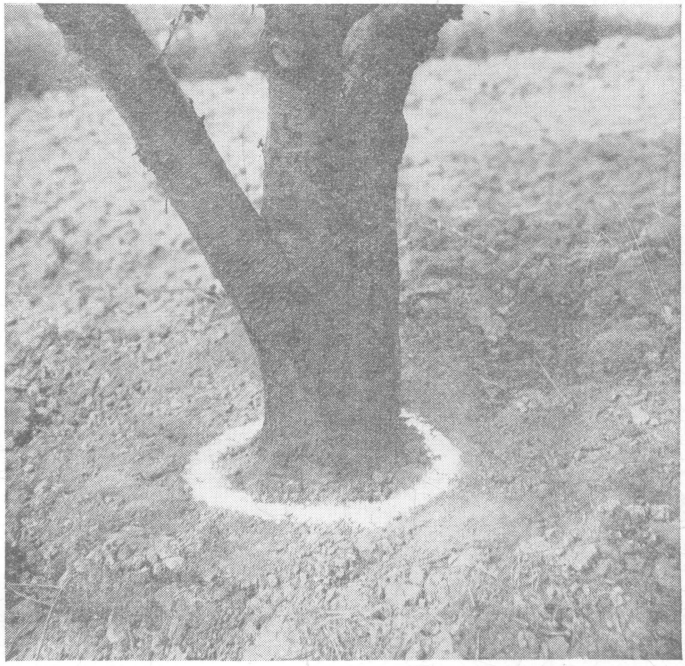

Fig. 19.—Paradichlorobenzene properly applied around base of tree, 2 inches from the trunk. Cover the chemical about 3 inches deep with a cone of earth, mounded against tree to confine gas in soil about channels of borers.

2.—Clear off the trash about the base of the tree for a distance of 6 inches from the trunk. Do not dig into the surface crust more than necessary. If considerable gum is present about the base of the tree, remove this before treating. Have the soil surface level with the highest point of gum exudation, and if necessary build up the dirt to this point. The gas given off by the chemical is heavier than air and is most effective below the point of application.

3.—The crystals of paradichlorobenzene are then evenly distributed in a narrow, continuous circular band on the soil about the tree. Place this ring about 2 inches from the trunk. Have the band about 1

inch wide, and none of it closer than 1 inch to the trunk (or large roots), otherwise injury to the tree might result (see Fig. 19).

4.—Place several shovels of soil (free from trash) over the ring of chemical. Pour the first shovelfuls of fine soil carefully against the base of the tree. Cover chemical about 3 inches deep with a cone of earth. Compact this with the back of the shovel or with the foot.

5.—*Airing.*—Three to four weeks after application, remove the mound of earth from the base of trees younger than four years. If the soil has been wet, wait from five to six weeks before uncovering. This is a precaution against possible injury to young trees. It is not necessary to remove the mounds from older trees. However, these mounds of earth should be leveled off in the spring.

A method has been developed recently whereby the paradichlorobenzene is dissolved in cottonseed oil and the solution sprayed in the correct amount directly on the soil around the base of the tree. This method has been tested in Georgia and Illinois where results were obtained comparable to those secured by the crystalline method. However, it possessed no advantages over the use of ethylene dichloride emulsion and was slightly more expensive.

*Ethylene Dichloride Emulsion*

Experiments conducted in several states have shown that ethylene dichloride emulsion is less likely to cause injury to young peach trees and is more effective at low temperatures than are paradichlorobenzene crystals. It is prepared by mixing ethylene dichloride and fish oil soap and then diluting with water. Different strengths of emulsion are required for trees of different age. For 7½ per cent strength emulsion (required for 1-year-old trees) mix ethylene dichloride 9 pints, soap 1 pint, and water to make 15 gals. This will treat 960 trees.

For 15 per cent strength emulsion (required for 2- and 3-year-old trees) mix ethylene dichloride 9 pints, soap 1 pint, and water to make 7½ gallons. This will treat 240 2-year-old, or 120 3-year-old trees.

For 25 per cent strength emulsion (required for average sized, mature trees) mix ethylene dichloride 9 pints, soap 1 pint, and water to make 4½ gallons. This will treat 72 mature trees.

The emulsion should be made outdoors, or in a well ventilated room. The air temperature should be above 50° F. Heat should *not* be used in making the emulsion, and the liquid should be *kept away* from fire, or open flame. Add the ethylene dichloride slowly, and at intervals, to the fish oil soap, agitating constantly to secure a good emulsion. Pumping the mixture back into itself in a bucket spray pump is an excellent method to use. When emulsified, add water slowly while agitating until the emulsion measures the correct amount for the strength desired.

This emulsion is now available commercially and ready to be applied to trees after the required amount of water is added.

The emulsion is applied by spraying or pouring the material on the base of the tree and on the soil immediately surrounding the trunk. Cupping the soil may be necessary to prevent run-off of liquid. The quantity to be applied should be regulated rather carefully. The recommendations of the U. S. Department of Agriculture are as follows: For 1-year-old trees, ⅛ pint of 7½ per cent emulsion; for 2-year-old trees, ¼ pint of 15% emulsion; for 3-year-old trees, ½ pint of 15% emulsion; and for average sized, mature trees, ½ pint 25% emulsion.

Methods of preparing the soil and mounding after treatment are the same as those employed in the use of paradichlorobenzene crystals.

There is little advantage gained by the use of this material on trees over 3 years old, provided the soil temperature is above 55° F. In treatments made late in the season, after cool weather arrives, and as an emergency in the spring before the soil becomes warm, this material has given a better kill, than paradichlorobenzene crystals.

### *Paint Treatment for Borers Located on the Trunk and Larger Limbs*

Fumigating with dry paradichlorobenzene crystals is not possible for controlling the lesser peach borer, which works entirely above ground on the trunk and older limbs. Considerable gum exudation is always found at points of larval feeding, which appears at abrasions on the trunk and in the crotches of the older limbs. Control consists of painting these wounds with crude cottonseed oil in which paradichlorobenzene is dissolved. The cost will amount to less than 1 cent per tree. Painting with ethylene dichloride emulsion is not effective.

*Directions for Preparing and Applying Paint.*—To prepare the mixture, dissolve 1 pound of paradichlorobenzene crystals in 2 quarts of crude cottonseed oil, previously warmed. Apply this mixture with a paint brush so that the bark is covered well beyond the edges of borer indications. Removal of gum, frass, or loose bark from the infested areas is not necessary.

There has been no discernible injury to peach trees so treated, but the paint should not be sprayed on or covered over more of the surface than necessary. The application should be made during mild weather the latter half of April or early in October. At this time of year the work of borers is easily visible. Inspection will reveal dead borers a few days after treatment.

It is preferable to use freshly prepared material. If the mixture is stored for a few days, place it in an airtight container. Linseed oil can be used instead of raw cottonseed oil, but it is not so easy to apply, being thicker and more sticky.

## RODENTS

It is extremely discouraging to a fruit grower to lose one or more of his best trees, because of injury from rabbits or mice. There are several methods the grower may use to prevent such rodent injury.

### *Tree Protectors*

Trunks of young trees may be protected against rabbit, woodchuck, and mouse injury by the proper use of wire guards. Guards made from ¼-inch mesh galvanized hardware cloth make an excellent protector. A cylinder of sufficient height and diameter can be made from squares cut from 24-inch width of this hardware cloth. This is high enough to prevent rabbit injury and, if pressed into the soil to a slight depth, usually will prevent mice from reaching the trunks. A convenient way to secure the cylinder is to use three or four hog rings at the lap of the wire.

A method of protecting trees that is used frequently against mice is to remove some of the soil for two to three feet away from around the base of the trunk in the fall and fill in with several shovels of weathered or leached cinders. This is an effective barrier against mice as long as mulch or trash does not collect on top of the cinders. This does not prevent damage when snow is on the ground and to the older roots that are near the surface.

### *Rabbit Paint*

The trunk and lower branches of young fruit trees may be protected against gnawing injuries from rabbits by painting with a resin-alcohol repellent in the fall before rabbit injury occurs and giving later applications as necessary. Usually one thorough application in the fall is sufficient each year, but where rabbits are very numerous an additional application may be needed in midwinter.

*Method of preparing rabbit paint.*—Use resin and alcohol in the proportion of 1 pound of resin to 1 pint of denatured alcohol. Warm the resin over a slow fire just to melting point but do not superheat it. Heat the alcohol to about the temperature of the resin. Do not heat the alcohol over a direct flame, but warm it in a pan or bottle immersed in hot water. Add the heated alcohol to the melted resin and stir to an even consistency. If the resin is too hot the alcohol will bubble and escape. Immediately place the preparation in a container that can be corked or sealed and keep sealed, except when in use. Keep snow and rain water out of the preparation, as moisture changes the texture of the paint.

Apply with a brush when bark is dry. Cover bark of trunk and lower limbs as far as rabbits can reach. Allow for snow which may permit rabbits to work higher on the trees.

Resin alcohol rabbit paint covers easily and is economical. It has been used extensively under Ohio conditions and found very effective in preventing rabbit damage.

Where neither wire guards nor repellents have been used, some degree of protection against rabbits can be secured in an emergency by scattering freshly cut prunings on the snow. The rabbits will often feed upon these in preference to the tree trunks.

### *Poisoned Baits for Mice*

Removing all weeds and grass from the area around the tree trunk in the fall is always advisable to guard against mouse injury. However, when mice are abundant, the use of poisoned baits is the only dependable method to use.

*Poison Stations.*—The bait should be placed in poison stations which are set close to the base of the tree and lightly covered with vegetation or prunings. If mice are abundant, place one station under each tree. The stations should be on high ground to avoid standing water. They may consist of pieces of board and lath nailed together to make a small mouse runway and also shelter the bait.

Drain tiles of 1½ inches diameter or larger, or hollow building tile serve fairly well. Wide mouth glass jars have been used successfully. The stations should be refilled with bait as required. Baiting should be done late in the fall and again during the winter or early spring if necessary.

*Two Good Formulas.*—The following formulas for preparing mouse bait are recommended by the Bureau of Biological Survey, United States Department of Agriculture:

*Rolled-oats bait.*—Mix together dry, ⅛ ounce of powdered strychnine and ⅛ ounce of baking soda. Sift the strychnine-soda mixture over 1 quart of rolled oats, stirring constantly to insure an even distribution of the poison through the grain. Thoroughly warm the poisoned rolled oats in an oven and sprinkle over them 6 tablespoonfuls of a mixture of 3 parts of melted beef fat and 1 part of melted paraffin, mixing until the oats are evenly coated. When the grain is cool it is ready for use.

A teaspoonful of the bait should be placed in each poison station. This poison may be placed also inside entrances of burrows. It should not be scattered in the open where birds will feed upon it.

*Starch-coated grain bait.*—Mix 1 tablespoonful of gloss starch in ½ teacup of cold water and stir into ¾ pint of boiling water to make a thin clear paste. Mix 1 ounce of powdered strychnine with 1 ounce of baking soda and stir into the starch to a smooth creamy mass free of lumps. Stir in ¼ pint of heavy corn sirup and 1 tablespoonful of gycerine. Apply to 12 quarts of wheat or to 20 quarts of steam-crushed whole oats and mix thoroughly to coat each kernel.

Steam-crushed whole oats are preferable as they may be scattered in the open without endangering bird life. This bait is prepared each summer at the Idaho Field Station of the U. S. Biological Survey. For information about sources of this poison, growers should consult their county agent, or state agricultural college.